

MARINE BENTHIC ALGAE AND THE ENVIRONMENT IN THE BAY OF

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MARINE BENTIC ALGAE AND THE ENVIRONMENT
IN THE ØRESUND

BY

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MARINE BENTIC ALGAE AND THE ENVIRONMENT

IN THE OCEAN

THOMAS W. HAYES

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MARINE BENTIC ALGAE AND THE ENVIRONMENT
IN THE ØRESUND. I-II.

BY

TORGNY VON WACHENFELDT

LUND 1975

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INTRODUCTION

The aim of the present investigation is to make a careful survey of the qualitative and a rough estimation of the quantitative composition of the benthic algal vegetation in the Öresund. Furthermore, the relevant environmental parameters are determined and their influence on the algal vegetation is briefly discussed.

The Öresund, as a transitional area between the Baltic and the Kattegatt - Skagerrack - North Sea (Fig. 1), has a unique but very complicated environment which gives good opportunity for the study of interactions between organisms and the environment. In an area with increasing pollution of the water it is essential to have careful descriptions of present conditions as grounds for evaluation of future changes.

HISTORICAL ASPECTS

Although several well-known algologists, such as C. A. Agardh, J. G. Agardh, Areschoug, Kjellman, Svedelius and Kylin have worked both in Lund and Uppsala with the Swedish marine algal flora, there are still gaps in our knowledge of the regional distribution and ecology of the flora. Relevant works are: "Handbok i Skandinavians hafsalgflora", Kjellman (1890); "Studien über die Algenflora der Schwedischen Westküste", Kylin (1907); "Die Rhodophyceen der schwedischen Westküste", Kylin (1944); "Die Phaeophyceen der schwedischen Westküste", Kylin (1947); "Die Chlorophyceen der schwedischen Westküste", Kylin (1949). From smaller areas can be mentioned "Studien über die Algenvegetation von Blekinge, Südschweden", Levring (1940) and "Rocky-shore algae in the Öregrund archipelago", Waern (1952). In Kylin's (1907) work there is no mention of the Öresund, as Kylin had his southernmost sampling station at Båstad. In Kylin's (1944, 1947, 1949) works there are some references to the Öresund but they are compiled from other sources.

There is some information about the algae in the Öresund in works by Liljeblad (1816), C. A. Agardh (1817, 1820, 1822, 1828), Fries (1835), J. G. Agardh (1836, 1841, 1848-63, 1876, 1882-83, 1894), Örsted (1844), Areschoug (1850, 1861-79, 1866, 1874, 1875), Lönnberg (1898, 1899), Simmons (1898), Rosenvinge (1909, 1917, 1923-24, 1931), Hylmö (1916), Sjöstedt (1927, 1928 a, 1928 b), Levring (1935), Suneson (1937, 1941, 1943), Waern (1940, 1945, 1965 a), Rosenvinge & Lund (1941, 1943, 1947), Lund (1950, 1956, 1967), Runemark (1960) and Kristiansen (1960, 1972). These works contain only small references to the Öresund area except Rosenvinge (loc.cit.), Levring (loc.cit.), Rosenvinge & Lund (loc.cit.) and Lund (1950). In the material from 1800 - 1900 there are many errors and in most cases there is no reliable preserved material.

DESCRIPTION OF THE AREA

The Öresund area is located between the Baltic and the Kattegatt (Fig. 1). In older literature, such as Areschoug (1850), it is called "fretum balticum" and traditionally the area has its north border-line between Kullen and Gilleleje and its south from Falsterbo to Dragör. In the present investigation the Öresund area is extended to the water from Hovs Hallar - Hallands Väderö - Raageleje to Falsterbo - Köge (Fig. 2).

The Öresund is a narrow straight between Zealand (Denmark) and Scania (Sweden). At the north entrance the distance between the shores is about 20 km. In the middle of the area from Helsingör to Helsingborg the distance is about 4 km, between Malmö and Copenhagen about 25 km and between the northern and the southern limits of the investigation area about 130 km.

The depths at the different sampling stations can be seen in Figs. 3 and 4 and in the sections in Fig. 5 a-d. In the northern part of the Öresund the depth is about 25 - 30 m, while from Helsingör to Helsingborg and south to Barsebäck it is about 15 - 20 m with a deeper furrow between Helsingör and Helsingborg and along the Swedish coast. In some small areas, such as Öretvisten west of Hittarp,

the Ven Deep east of Ven and the Landskrona Deep, one can find depths of up to 45 - 50 m. Between Malmö and Copenhagen there is a threshold where the depth is only 8 m and somewhat deeper near Copenhagen. South of this sill the depth increases to 10 - 15 m.

In the Öresund there are many types of bottom, from solid rock at Mount Kullen and large boulders mixed with sand along the Swedish coast to firm sandstone, gravel and soft bottoms. Shell bottoms are found near Helsingborg and Landskrona. Some parts consist of fine sand, e.g. near Gilleleje, Helsingör (Disken) and north-west of Skanör, with very few algae because of heavy sand suction (Fig. 6). The bottom conditions at the different stations for collection of algae are given in the designation on pp. 11 - 15.

THE LOCAL CLIMATE

The average local climate for the Öresund area according to "Atlas över Sverige", section on meteorology, can be represented by the following data:

1. Mean air temperature.

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
0	0	2	5	10	14	16	16	13	9-8	5-4	2-1

°C.

2. Seasons.

Spring (0° to +10°C.)	Begins at about the 20th of February and has a duration of 80 - 90 days.
Summer (more than +10°C.)	140 days from the 10 - 20th of May to the end of September. The number of days with the average temperature above +15°C. is about 60.
Autumn (+10° to 0°C.)	From the 1st - 10th of October to the middle of January, about 100 - 110 days.
Winter (less than 0°C.)	About 20 - 40 days from the 10th of January or the 1st of February. The annual number of days without frost is about 280.

3. Precipitation.

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
40	30	30	40	40	50	60	70	50	50	50	40

mm

The given values are mean values for the period 1901 - 1930. There is of course a large variation from this general view. Generally speaking, during the investigation period the winters have been longer and colder than average. There was ice for more than a month during 1965, 1966, 1969 and 1970. The number of days of sun and overcast are seen in Fig. 7.

POLLUTION

The Öresund area is a recipient of sewage directly or indirectly (by rivers) from a population of approximately 2.5 million. The Sound also receives sewage from well-developed industries; including a large fertilizer plant and a combined sulphuric and phosphoric acid plant. The pollution load has changed the marine environment in many respects and many of the changes which are described in connection with the different parameters are due to the increasing pollution.

METHODS

The investigation started on a small scale in 1963 and the main part of the investigation was carried out from 1966 to 1972. The work has been done at the Institute of Systematic Botany at the University of Lund. For most of the field work the research vessel of the University of Lund, "Carolina", has been used. In some cases the research vessel "Thetis" from the Royal Fishery Board of Sweden, the research vessel "Ophelia" from the Marine Biological Institute in Helsingör (the University of Copenhagen) or ships from the Royal Coastguards of Sweden and Denmark were used.

Algae were collected from 104 different stations (Fig. 3 and pp. 11 - 15). The stations were chosen, as far as possible, to represent all kinds of bottoms, depths and types of wave exposure. Of the 104 stations collection has been made from a boat at 42 stations, from the shore at 62 stations. With few exceptions, such as Kullen, the shores are sandy. The collection from the shore was, therefore, concentrated to jetties and harbours. As far as possible the stations were visited several times a year and in most cases material was collected from the stations every year to get a view of the seasonal and yearly variation in the floral composition. At every station ca. 200 - 300 m of the bottom have been surveyed and at most shore stations vegetation profiles have been made. In this way it has also been possible to detect changes due to pollution and other changes in the environment.

To collect the algae the author mainly used a triangle dredge or on soft bottoms a fine-meshed herring trawl. Near the shores a hand dredge was used or the algae were collected by hand. Now and then help was recieved from SCUBA-divers and in some cases the author himself did the diving work. After a rough assortment in the field the material was brought to the Marine Botanical Laboratory in Lund for determination. The material is kept dried in the herbarium or preserved in formalin or as microscopic slides. The material will be kept in the Botanical Museum of the University of Lund.

Hydrographical samples have been taken at 149 stations (Fig. 4, pp. 15 - 18). These water samples for different analyses have been collected by means of Nansen, Pedersen or N.I.O. water samplers or with an all-plastic sampler of Rutner type. The methods for the different analyses will be described under the discussion of each parameter.



Fig. 1. Southern Scandinavia with the location of the present investigation area.

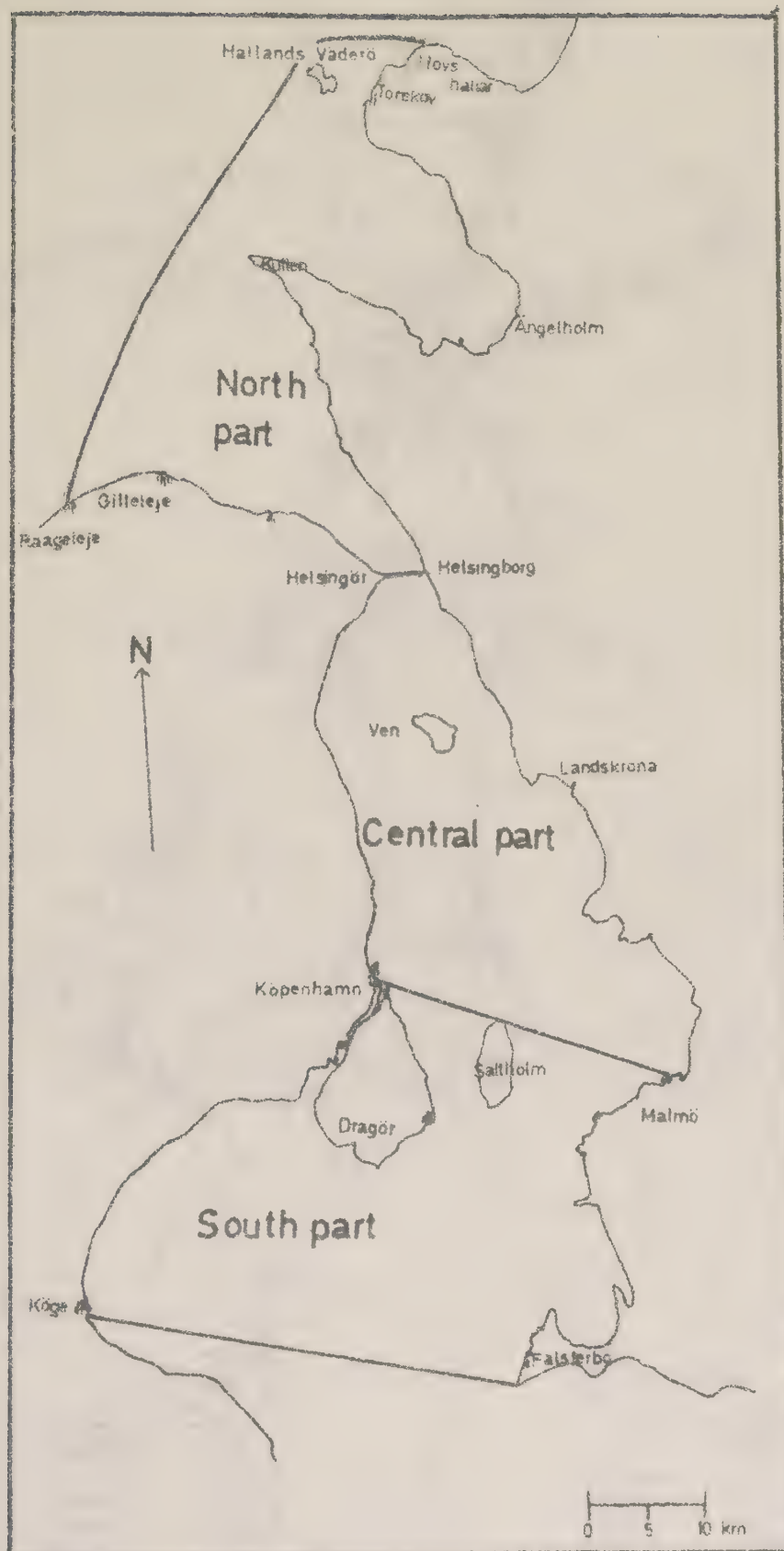


Fig. 2. The investigation area with the borders of the north, central and south part of the area.



Fig. 3. Sampling stations for algae.

○ Sample taken from boat. ▲ Sample taken from shore.

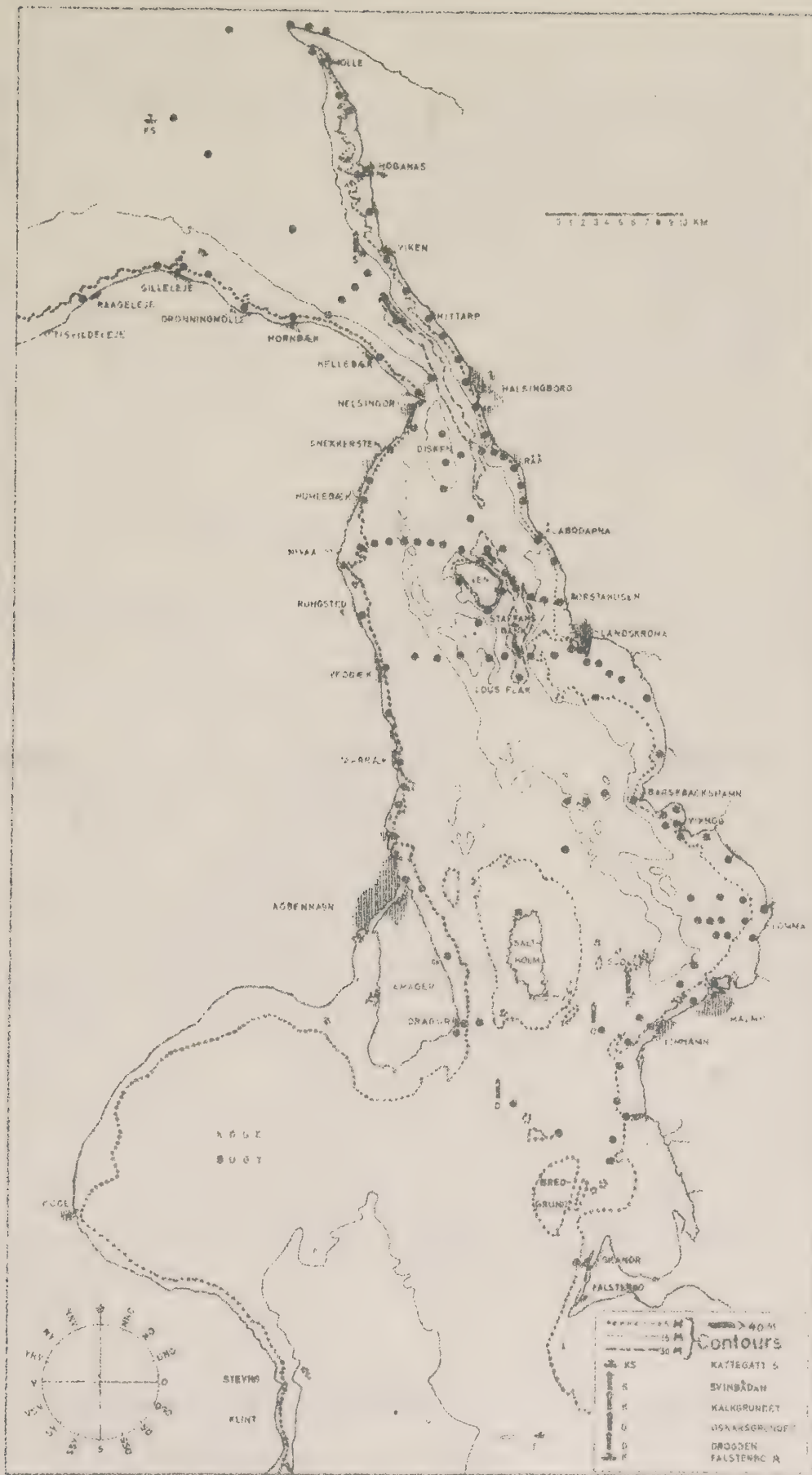


Fig. 4. Hydrographical sounding chart.

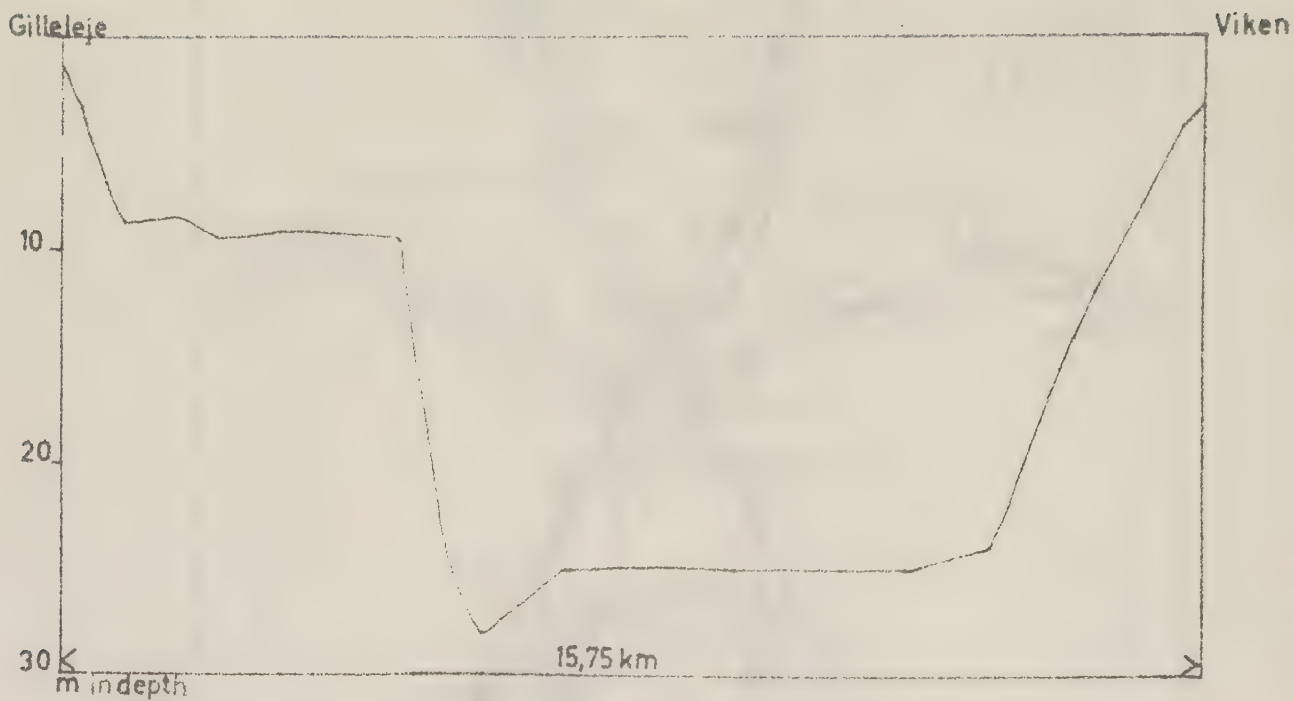


Fig. 5 A.

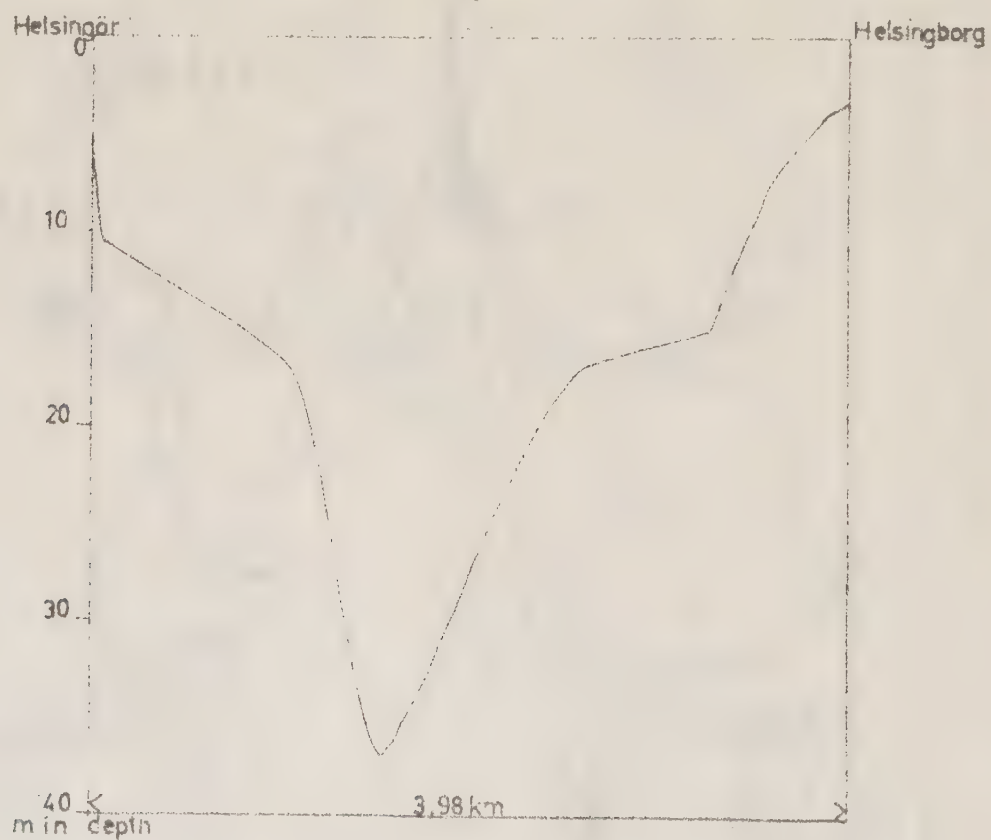


Fig. 5 B.

Fig. 5 A - D. Depth profiles.

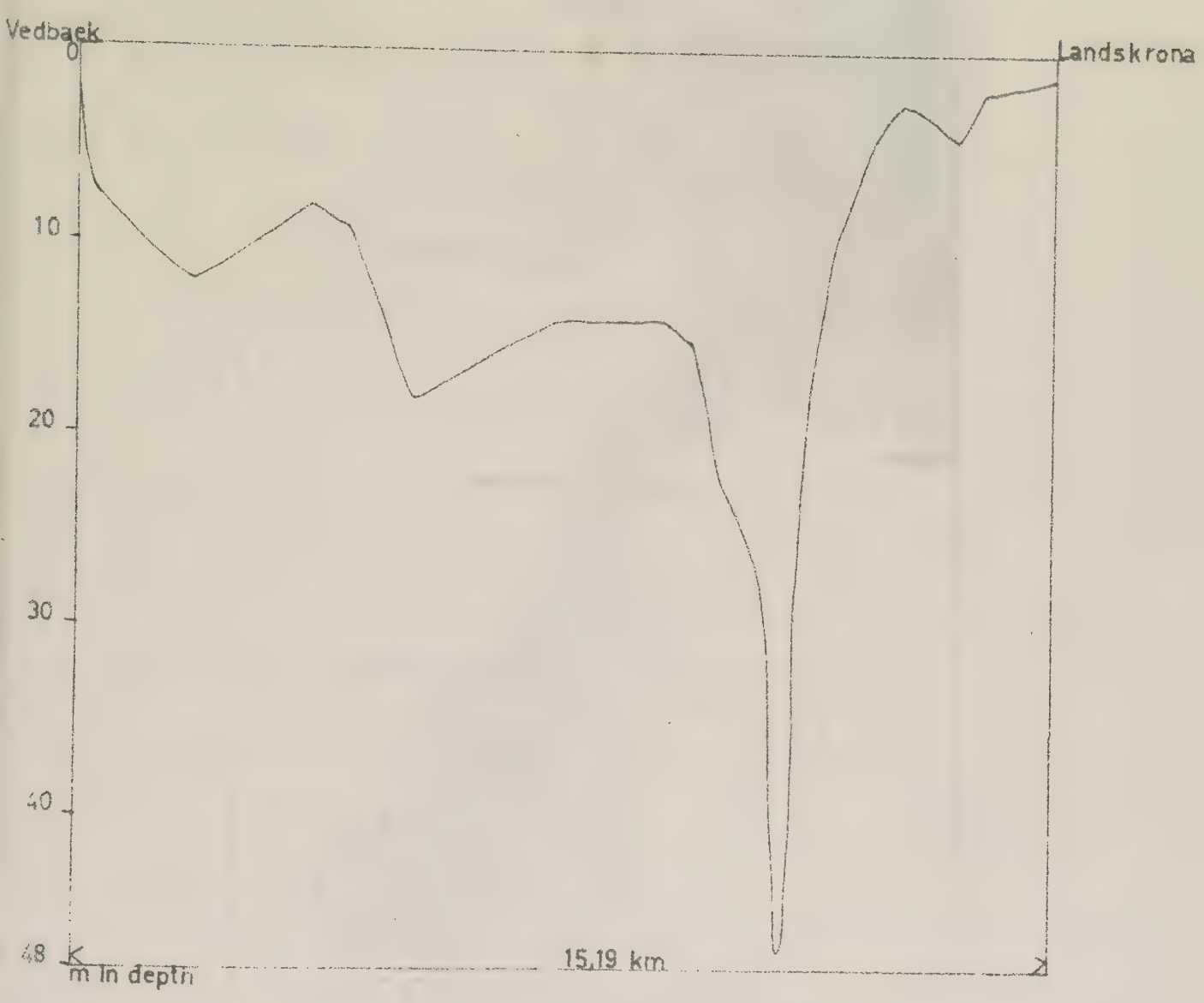


Fig. 5 C.

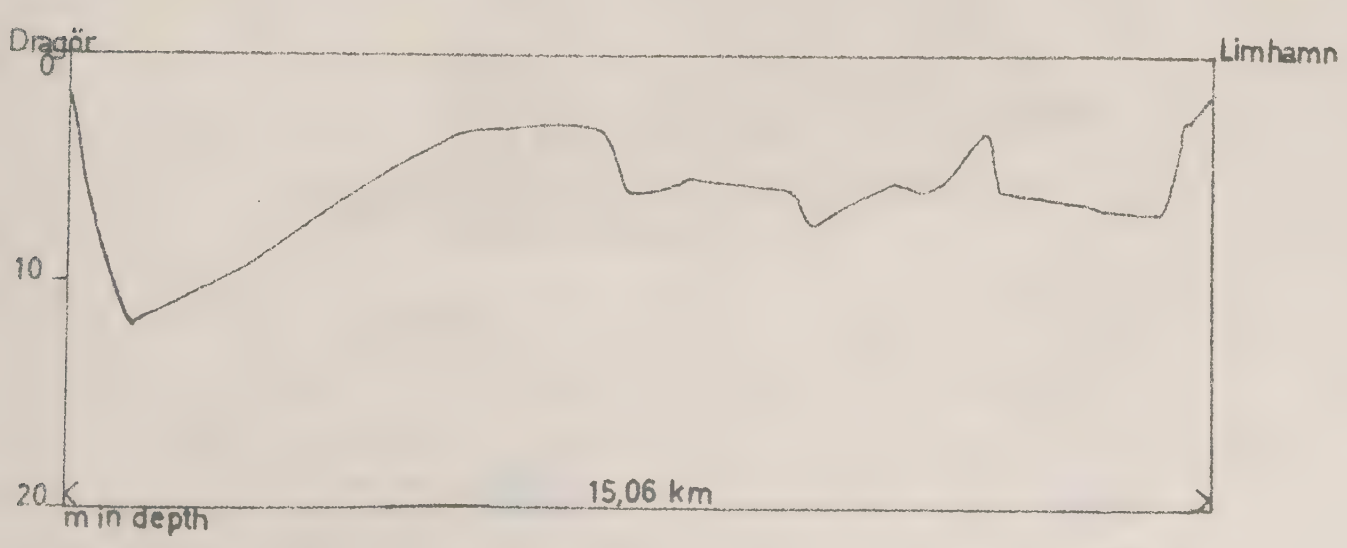


Fig. 5 D.

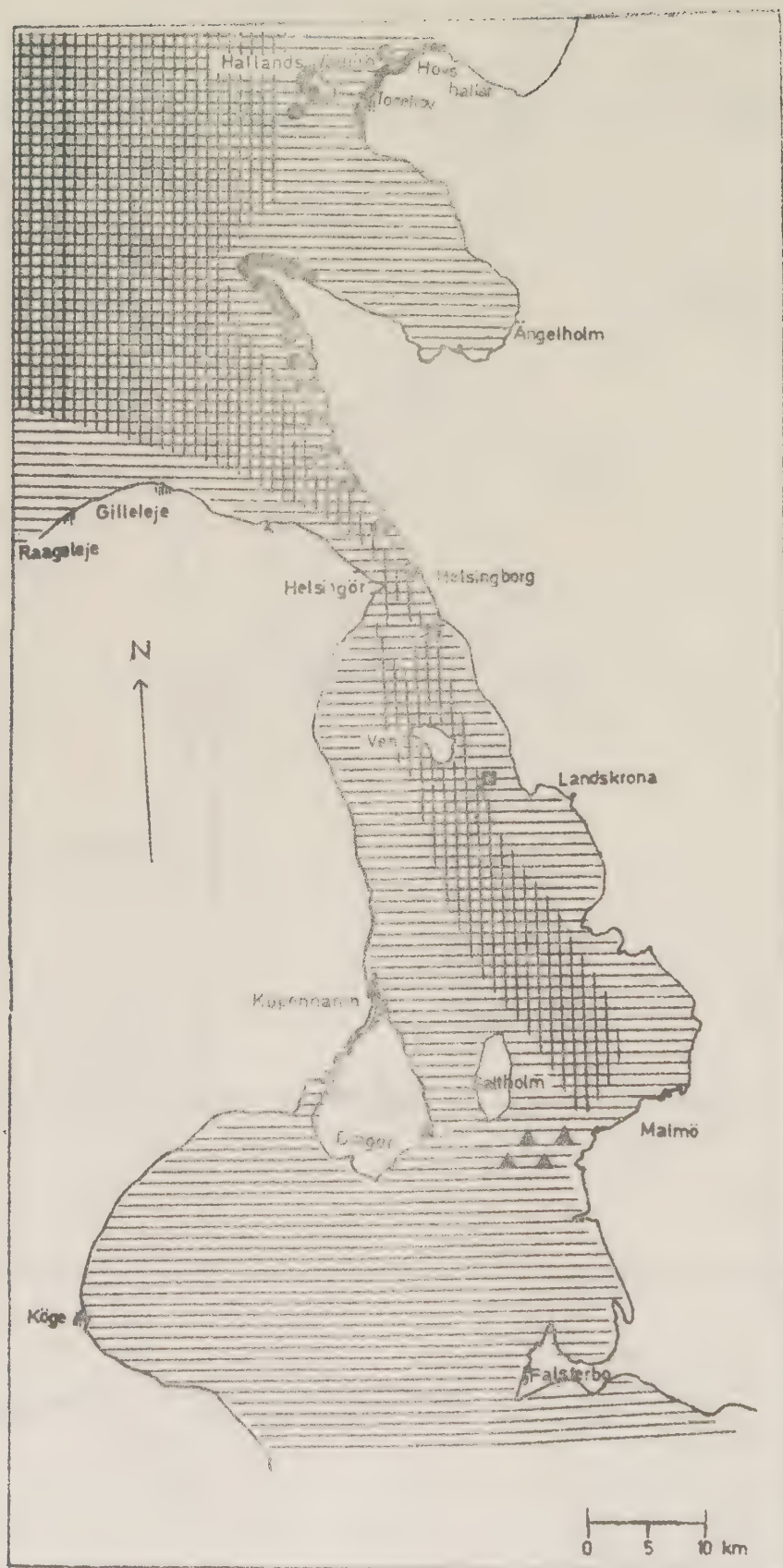


Fig. 6. Schematic map of the bottom conditions in the Öresund area.

- | | | | |
|-------|---|-------|---|
| ===== | sand bottom more or less mixed with stone | +++++ | clay bottom more or less mixed with stone |
| ■ | rocks | ● | shell-gravel |
| | | ▲ | limestone mixed with flint |

Station designation.

	N.	E.	
1	55°24'	12°46'	W. Falsterbo, about 10 m. Sand bottom. Triangle dredge.
2	55°25'	12°50'	The harbour of Skanör, 0-3 m. Stone bottom and stone reef.
3	"	12°56'	The north end of the Falsterbo Canal, 0-5 m. Stone bottom.
4	55°26'	12°48'	NW. Skanör, about 5 m. Sand bottom with some stones. Triangle dredge.
5	55°28'	12°46'	W. Bredgrund, about 7-8 m. Stone and sand bottom. Triangle dredge.
6	55°29'	12°09'	N. Köge, 0-1 m. Sand with pebbles.
7	55°30'	12°52'	SW. Klagshamn, 5-7 m. Pebbles and sand. Triangle dredge.
8	55°31'	12°54'	Klagshamn, 0-3 m. Stone bottom and stone reef.
9	55°32'	12°43'	The lighthouse of Drogden, about 10 m. Stone bottom (flint). Triangle dredge.
10	55°33'	12°45'	NE. Drogden, about 10 m. Stone bottom (flint, limestone). Triangle dredge and diving.
11	"	12°52'	NW. Klagshamn, 6-8 m. Flintstone. Triangle dredge.
12	55°34'	12°47'	S. Saltholm, 5-10 m. Stone bottom (flint, limestone). Triangle dredge.
13	"	12°48'	Oskarsgrundet SW, 7-10 m. Stone bottom (flint, limestone). Triangle dredge and diving.
14	"	12°54'	Lernacken, 0-3 m. Limestone pebbles.
15	55°35'	12°56'	Limhamn, 0-3 m. Limestone.
16	55°36'	12°41'	The harbour of Dragör, 0-3 m. Stone bottom.
17	"	12°42'	E. Dragör, 5-8 m. Stone bottom and clay. Triangle dredge.
18	55°37'	12°54'	Kalkgrundet, 5-10 m. Stone bottom (flint, limestone). Triangle dredge and diving.
19	"	13°00'	The harbour of Malmö, 0-3 m. Stone bottom.
20	55°38'	12°59'	The roads of Malmö, 13-15 m. Mud with stones. Triangle dredge.
21	55°39'	13°03'	S. Lomma, 0-1 m. Sand with pebbles and shells.

	N.	E.	
22	55°40'	12°44'	NW. Saltholm, 0-3 m. Shelving soft sandstone.
23	"	12°46'	NE. Saltholm, 0-1 m. Soft sand bottom with stones.
24	"	12°59'	The Lomma bay, 10-13 m. Muddy bottom with isolated stones. Triangle dredge and trawl.
25	55°41'	12°39'	E. Köbenhavn, 8-10 m. Mud, H ₂ S. Triangle dredge.
26	"	13°04'	The harbour of Lomma, 0-2 m. Stone bottom.
27	55°42'	12°59'	Lomma bay, 10-18 m. Mud, stones and shells. Triangle dredge and trawl.
28	"	13°01'	Bjärred, 0-2 m. Sand and pebbles.
29	55°44'	12°42'	10 m. Sand, mud, pebbles and shells. Triangle dredge.
30	"	12°48'	9 m. Sand, mud, pebbles and shells. Triangle dredge.
31	"	12°51'	13 m. Sand, mud, pebbles and shells. Triangle dredge.
32	"	12°56'	W. Vikhög, 7-12 m. Stones. Triangle dredge.
33	"	12°57'	Saltvik, 5 m. Sand with mud and stones. Triangle dredge.
34	"	12°58'	The harbour of Vikhög, 0-2 m. Stone bottom.
35	55°45'	12°54'	The harbour of Barsebäck, 0-3 m. Stone bottom.
36	55°46'	12°36'	The harbour of Skogshoved, 0-2 m. Stone bottom.
37	"	12°55'	Sjöbobaden, 5-8 m. Coarse sand and pebbles. Triangle dredge.
38	55°47'	12°36'	Taarbaek, 0-2 m. Stone bottom.
39	"	12°56'	N. Sjöbobaden, 0-1 m. Stones and pebbles.
40	55°48'	12°54'	Lundåkra bay, 5-7 m. Stones. Triangle dredge.
41	"	12°56'	Lundåkra bay, 0-1 m. Stones and pebbles.
42	55°51'	12°34'	Vedbaek, 0-2 m. Stone bottom.
43	"	12°52'	S. Landskrona, 0-1 m. Sand, pebbles and shells.
44	55°52'	12°48'	Gräsrännan, 3-5 m. Sand, pebbles and shells. Triangle dredge.
45	"	12°49'	The harbour of Landskrona, 0-2 m. Stone bottom.
46	55°53'	12°33'	Rungsted, 0-2 m. Stone bottom.

	N.	E.	
47	55°53'	12°43'	S. Ven, 0-2 m. Sand and stones.
48	"	12°45'	Staffansbank, 10-30 m. Shell gravel. Triangle dredge.
49	"	12°49'	N. Landskrona, 0-1.5 m. Sand, stones and stone bottom.
50	55°54'	12°44'	Bäckviken, 0-2 m. Sand mingled with stones.
51	"	12°45'	The "Ven-deep", 20-40 m. Mud with stones. Triangle dredge.
52	"	12°48'	The harbour of Borstahusen, 0-2 m. Stone bottom.
53	55°55'	12°31'	Nivaa pier, 0-2 m. Stone bottom.
54	"	12°40'	The harbour of Kyrkbacken, 0-2 m. Stone bottom.
55	"	12°42'	The harbour of Norrebro, 0-2 m. Stone bottom.
56	55°56'	12°40'	N. Ven, 20-30 m. Stone bottom with patches of sand. Triangle dredge.
57	"	12°46'	The harbour of Alabodarna, 0-2 m. Stone bottom.
58	55°58'	12°33'	Humblebaek, 0-2 m. Stone bottom.
59	"	12°46'	Fortuna, 0-2 m. Sand and stone bottom.
60	55°59'	12°45'	The harbour of Råå, 0-2.5 m. Stone bottom.
61	56°00'	12°42'	Knähaken, 7-15 m. Firm sand bottom and stones. Triangle dredge.
62	56°01'	12°35'	Snekkersten, 0-2.5 m. Stone bottom and stones.
63	"	12°38'	W. Disken, 10-12 m. Sand, few pebbles and shells. Triangle dredge.
64	"	12°42'	The harbour of Kopparverket, 0-2 m. Stone bottom.
65	56°02'	12°37'	The north harbour of Helsingör, 0-3 m. Stone.
66	"	12°39'	The north point of Disken, 10-12 m. Sand. Triangle dredge.
67	56°03'	12°41'	The harbour of Helsingborg, 0-15 m. Stone bottom. Diving.
68	56°04'	12°34'	Hellebaek, 0-2 m. Sand, stones and pebbles.
69	"	12°40'	Tinkarp, 0-2 m. Sandstone and stone bottom.
70	56°05'	12°38'	SW. Hittarp, 8-14 m. Sandstone. Triangle dredge.

	N.	E.	
71	56°06'	12°10'	Raageleje, 0-2 m. Sand with stone reef.
72	"	12°24'	Dronningmölle, 0-2 m. Sand mingled with stones.
73	"	12°28'	The harbour of Hornbaek, 0-2 m. Stone bottom.
74	"	12°30'	Hornbaek plantage, 0-2 m. Sand, stone and pebbles.
75	"	12°31'	Ellekilde hage, 8-25 m. Sand with patches of mud and stones. Triangle dredge and trawl.
76	"	12°38'	Hittarp, 0-2 m. Stone reef.
77	56°07'	12°35'	Grällegrund, 7-20 m. Heavy "moraine stone". Triangle dredge and diving.
78	"	12°36'	Domsten, 0-2 m. Stone bottom.
79	56°08'	12°10'	N. Raageleje, 10-15 m. Stone bottom mingled with sand. Triangle dredge.
80	"	12°19'	The harbour of Gilleleje, 0-3 m. Stone bottom. Diving.
81	"	12°35'	The harbour of Viken, 0-2 m. Stone bottom.
82	56°09'	12°17'	W. Gilleleje flack, 8-15 m. Stone bottom. Triangle dredge.
83	56°10'	12°20'	N. Gilleleje flack, 15-25 m. Stone bottom. Triangle dredge.
84	56°11'	12°33'	The harbour of Lerberget, 0-2 m. Stone bottom.
85	56°12'	12°33'	The harbour of Höganäs, 0-3 m. Stone bottom.
86	56°15'	12°29'	W. Nyhamnsläge, 15-20 m. Stone bottom. Triangle dredge.
87	"	12°31'	Lerhamn, 0-3 m. Stone bottom. Diving.
88	"	12°32'	The harbour of Nyhamnsläge, 0-3 m. Stone bottom.
89	56°16'	12°29'	W. Vattenmöllan, 20 m. Rocky bottom. Triangle dredge.
90	56°17'	12°28'	W. Ransvik, 20-25 m. Rocks. Triangle dredge and diving.
91	"	12°29'	The entrance fairway of Mölle, 7-10 m. Coarse sand and stones. Triangle dredge.
92	"	"	Ransvik, 0-20 m. Rocks. Diving.
93	"	"	Solvik, 0-6 m. Rocks. Diving.

	N.	E.	
94	56°17'	12°30'	The harbour of Mölle, 0-2 m. Stone bottom and rocky bottom.
95	"	12°34'	Arild, 0-5 m. Rocks. Diving.
96	56°18'	12°27'	The cape of Kullen, 0-10 m. Rocky bottom. Diving.
97	"	12°28'	Ablahamn, 0-15 m. Rocks. Diving.
98	"	12°30'	Djupadal, 0-6 m. Rocks. Diving.
99	56°26'	12°34'	The south point of Hallands Väderö, 0-3 m. Rocks.
100	"	12°36'	SE. Hallands Väderö, 15-20 m. Stones. Triangle dredge.
101	"	12°38'	The harbour of Torekov, 0-2 m. Rocks.
102	56°27'	12°33'	The north-west point of Hallands Väderö, 0-3 m. Rocks. Diving.
103	"	12°37'	E. Hallands Väderö, 10-22 m. Stones. Triangle dredge.
104	56°28'	12°42'	Hovs Hallar, 0-6 m. Rocks. Diving.

Hydrographical sampling stations.

N.	E.		N.	E.	
55°25'	12°50'	Skanör	55°36'	12°42'	E. Dragör
55°29'	12°53'	S. Klagshamn	"	12°55'	SE. Kalkgrundet
55°30'	12°48'	N. Bredgrund	"	12°58'	Ribersborg
"	12°53'	S. Klagshamn	55°37'	12°57'	W. Malmö
55°31'	12°54'	Klagshamn	"	13°00'	Malmö
55°32'	12°45'	E. Drogden	55°38'	12°40'	Kastrup
"	12°53'	N. Klagshamn	"	12°58'	NW. Malmö
55°34'	12°53'	Lernacken	55°39'	13°00'	Lomma bay
55°35'	12°41'	S. Dragör	"	13°01'	"
"	12°52'	Oskarsgrundet	"	13°03'	S. Lomma
"	12°53'	W. Limhamn	55°40'	12°44'	Saltholm
"	12°56'	Limhamn	"	12°58'	Lomma bay
55°36'	12°41'	Dragör	"	12°59'	"

N. 55°40'	E. 13°00'	Lomma bay	N. 55°50'	E. 12°54'	Lundåkra bay
"	13°02'	"	55°51'	12°34'	Vedbaek
55°41'	12°39'	E. Köbenhavn	"	12°51'	Lundåkra bay
"	12°57'	Lomma bay	"	12°52'	"
"	13°00'	"	55°52'	12°37'	E. Vedback - W. Landskrona
"	13°02'	"	"	12°39'	"
"	13°04'	Lomma	"	12°41'	"
55°42'	12°37'	Tre Kroner	"	12°43'	"
"	13°01'	Bjärred	"	12°44'	"
55°43'	12°48'	NE. Saltholm	"	12°46'	"
55°44'	12°35'	Hellerup	"	12°48'	Gräsrännan
"	12°56'	Saltvik	"	12°49'	Landskrona
"	12°57'	"	"	12°50'	"
"	12°58'	Vikhög	55°53'	12°33'	Rungsted
"	12°59'	Lomma bay	"	12°42'	S. Ven
55°45'	12°35'	Charlottenlund	"	12°43'	Ven, the south cape
"	12°48'	W. Barsebäck	55°54'	12°44'	Bäckviken
"	12°50'	"	"	12°45'	The "Ven-deep"
"	12°52'	"	"	12°46'	F. Ven
"	12°54'	Barsebäckshamn	"	12°47'	"
"	12°56'	Saltvik	"	12°48'	Borstahusen
"	12°57'	"	55°55'	12°31'	Nivaa pier
55°46'	12°36'	Skogshoved	"	12°40'	Kyrkbacken
55°47'	12°36'	Taarbaek	"	12°42'	Norreborg
"	12°56'	N. Sjöbobaden	"	12°44'	E. Ven
55°49'	12°35'	Skodsborg	55°56'	12°32'	Nivaa - Ålabodarna
"	12°51'	Lundåkra bay	"	12°33'	"
"	12°56'	"	"	12°34'	"
55°50'	12°44'	E. Lous flak	"	12°35'	"
"	12°53'	Lundåkra bay	"	12°36'	"

N.	E.		N.	E.	
55°56'	12°37'	Nivaa - Ålabodarna	56°05'	12°39'	Laröd
"	12°38'	"	56°06'	12°10'	Raageleje
"	12°41'	"	"	12°24'	Dronningmølle
"	12°43'	"	"	12°28'	Hornbaek
"	12°44'	"	"	12°30'	Hornbaek - Viken
"	12°46'	Ålabodarna	"	12°36'	Øretvisten
"	12°48'	S. Ålabodarna	"	12°38'	Hittarp
55°57'	12°41'	N. Ven	56°07'	12°31'	Hornbaek - Viken
55°58'	12°33'	Humblebaek	"	12°32'	"
"	12°46'	Rydebäck	"	12°35'	Grälleggrund
55°59'	12°34'	Espergaerde	"	12°36'	Domsten
"	12°39'	Disken	56°08'	12°17'	W. Gilleleje
"	12°45'	Råå	"	12°19'	Gilleleje
"	"	Örby ängar	"	12°21'	N. Nakkehoved
55°00'	12°39'	Disken	"	12°33'	Hornbaek - Viken
"	12°41'	SW. Kopparverket	"	12°35'	Viken
"	12°42'	S. Kopparverket	56°09'	12°33'	Svinbådan
"	12°43'	"	56°10'	12°28'	NW. Svinbådan
"	12°44'	Råå vallar	56°11'	12°33'	Lerberget
56°01'	12°35'	Snækkersten	56°12'	12°33'	Höganäs
"	12°37'	S. Helsingör	56°13'	12°22'	SE. Kattegatt " South
"	12°33'	Disken	56°15'	12°19'	E. Kattegatt South
"	12°42'	N. Kopparverket	"	12°31'	Lerhamn
56°02'	12°37'	Helsingör, the north harbour	"	12°32'	Nyhamnsläge
"	12°42'	Helsingborg, the south harbour	56°17'	12°29'	Ransvik
56°03'	12°41'	N. Helsingborg	"	12°30'	Mølle
56°04'	12°39'	Hellebaek	56°18'	12°24'	W. the lighthouse of Kullen
"	12°38'	Lappegrund	"	12°27'	The lighthouse of Kullen
"	12°49'	Tinkarp	"	12°26'	Ålabodarna

N.	E.		N.	E.	
56°18'	12°30'	Djupadal	56°27'	12°36'	E. Hallands
					Väderö
56°26'	12°36'	E. Hallands	56°29'	12°30'	NW. Hallands
		Väderö			Väderö
"	12°37'	W. Torekov			

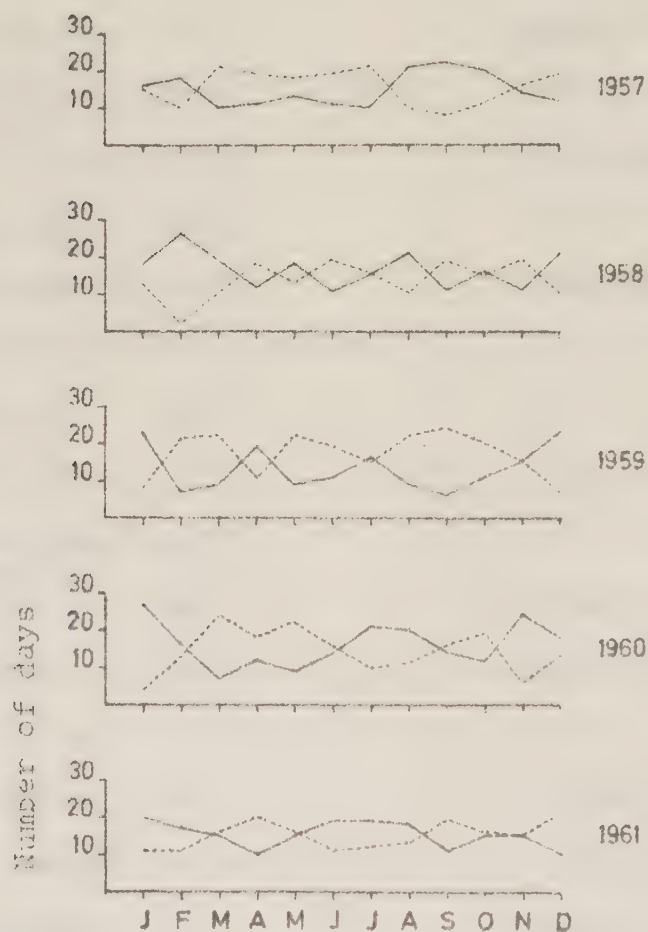


Fig. 7. Number of days with sun and overcast for each month at Lappegrund 1957-1961.

..... sun _____ overcast

Calculated from Nautisk-Meteorologisk Årbog.

ENVIRONMENTAL FACTORS

In this section some environmental factors which are important for the composition, development and productivity of the marine flora will be described. For each parameter the method of determination and values are given. The influence the parameters have on the flora will be discussed in a later section.

The hydrographical conditions in the Öresund have been dealt with by, i.a. Sjöstedt (1936), Brattström (1941), Dahl (1946, 1948) and the first Report on the Investigations of The Swedo-Danish Committee on Pollution of The Sound 1959-64 (1967). There are also very valuable series of daily measurements of salinity and temperature from Swedish and Danish lightships from 1880 and forward with the exception of the years 1940-48. These measurements ended at Svinbådan in 1960, at Lappegrund in 1968 and at Oskarsgrundet in 1962, when the ships were succeeded by unmanned devices. Measurements have, however, been taken up at the Kattegatt South lightship from 1967.

SALINITY

The salinity has been determined by three different methods:

1. Titration with silver nitrate according to Knudsen (1901).
 2. In situ salinometer, Beckman RS 50.
 3. Normameter with Philips electrode 9513 at 20°C, the main method used.
- All determinations have been checked against International Standard Sea-water. The accuracy is about 0.1 o/oo which is sufficient for biological purposes. Tempered glass flasks with steel stoppers with polyethene inserts have been used for transport and storage of the samples.

The values of salinity, which now number some 4000 determinations, have mostly been used in connection with the distribution of different species of algae in relation to depth and salinity (section II, Figs. 78, 83 and similar). The statistical analysis of the salinity variation is mainly founded on the measurements from the Swedish and Danish lightships.

In areas where fresh or brackish waters meet more saline waters, there is usually a rapid mixing of the different water masses due to tide phenomena. In such areas regular changes in the salinity occur at regular intervals. In the Öresund area where low saline Baltic water (about 7-8 o/oo) meets the more saline water of the Kattegatt and Skagerack, there is, however, very little tide: about 10 - 15 cm. As a result, there is a salinity gradient from south to north which gives a unique opportunity for ecological studies of the effects of changes in salinity on marine organisms. This gradient is summarized in Fig. 8. However, the gradient is not stable, due to the influx of Baltic and Kattegatt water depending on winds and currents. The result is an extremely complicated set of changes at different depths. Between the Baltic and Kattegatt water bodies a halocline is usually established from about 9 to 15 m in depth (Fig. 15 A).

There are several kinds of salinity fluctuation in the gradient, e.g. daily, seasonal and long-term. The daily salinity variations are most frequent (Fig. 9). Even during one day the salinity may vary often and considerably (Fig. 10). The different kinds of fluctuations will be described and discussed with examples from six different parts of the Sound: the lightship of Kattegatt South at the entrance to the Öresund, the lightships of Svinbådan, Lappegrund and Oskarsgrundet, the Drogden lighthouse and the lightship of Falsterbo Reef in the Baltic proper, just south of the Öresund area (Fig. 3).

A general picture of the limits within which the salinity can vary at different depths and in various parts of the Öresund area during three years is given in Table 1. The values are based on the same material as in Fig. 11 A - S and Table 2.

Table 1. Salinity amplitude (extreme low and high values of salinity) in o/oo at different depths and localities.
Calculated from Hydrographical Observations on Swedish Lightships and Oceanografiske Observationer fra Danske Fyrskibe og Kyststationer.

Depth	Kattegatt S 1967-69	Svinbådan 1958-60	Lappegrund 1964-66	Oskarsgrundet 1959-61	Falsterbo Reef 1959-61
0 m	10-32	9-30	8-26	6-28	7-12
5 m	10-34	8-33	8-27	7-31	7-12
10 m	14-34	10-34	8-34	7-32 ³	7-12
15 m	16-35	11-34 ¹	10-35		
20 m	20-36	12-35 ²		1 = 14 m 2 = 17 m	
25 m	21-36			3 = 8 m	

As can be seen in Table 1, there is a trend to higher values with depth and lower salinity toward the southern part of the area. The Malmö - Copenhagen threshold effect on the salinity amplitude is striking. The data above, however, give only a rough picture of the conditions under which the organisms live. It is necessary, therefore, to study local areas and the different types of fluctuations in all parts of the investigated region. To get a more accurate picture of the salinity conditions, one can start by noting the distribution of the salinity values at different depths and stations (Fig. 11 A - S). One of the striking facts that can be observed is the more or less skew distribution of the salinity classes in both the surface and bottom layers. Therefore, it is inappropriate to calculate mean values. For that reason the quartiles q_1 , q_2 , q_3 , the quartile range $q_3 - q_1$, the variation breadth R and the skewness g_1 have been calculated. The values can be found in Table 2.

To get an impression of the daily salinity variation in different parts of the area and at different depths, one can calculate the number of changes in salinity exceeding 1.5 o/oo from day to day. For practical reasons the number of changes every month is divided by the number of measurements and multiplied by 100. As can be seen in Fig. 12 A - K, there is a great salinity variation at different depths and seasons. At Kattegatt South there is a tendency to high values in the surface layer, with slightly lower values from July to September. At a depth of 5 m the salinity is more stable with a minimum in September. At both 10 and 15 m the frequency of changes is higher than at 0 and 5 m, as could be expected due to the oscillation of the halocline. There is a tendency for higher rather than lower values during summer. The lowest values at 10 m occur from March to May and in November and December. At 15 m the minimum values occur in February and November. The salinity situation at depths of 20 and 25 m is more stable, with very few changes during late spring and summer. At 20 and 25 m the main fluctuation of the year occurs in February and from October to December. At Lappegrund the situation is similar to that at Kattegatt South, although the number of changes at 10 and 15 m is somewhat higher. At Oskarsgrundet on the Malmö - Copenhagen threshold where Kattegatt and Baltic waters meet, the frequency of changes is high (Fig. 12 E-F) with the exception of February and March. In these months there are no or very few changes. At this station one can also see lower values in the surface layers during June but at depths of 5 and 8 m the values are high. At Drogden (Fig. 12 G), southeast of Copenhagen, where the water is in general more saline than on the Swedish coast, the fluctuation is somewhat lower than at Oskarsgrundet. At Falsterbo Reef in the Baltic proper, just outside the border of the Öresund area,

the situation is alike at all depths with few changes from January to September.

To get a view of the seasonal variation in salinity, the monthly mean values are important. As can be seen in Fig. 13, there may be a variation from year to year at the same locality and depth, although the trend is similar. In Fig. 14 is shown the monthly mean salinity variation at different depths from four parts of the Öresund area, calculated for a period of three years. The general tendency at Kattegatt South at 0 and 5 m is lower values from May to September. At depths below 15 m the seasonal variation is not so high. At 20 and 25 m the values are stable with somewhat lower values from October to December. The conditions are similar at the other stations except at Falsterbo Reef, where the monthly salinity values at all depths differ very little during the whole year.

East-west variation in salinity. As an effect of the Coriolis force, brackish less-dense water is forced eastwards to the Swedish side of the Öresund by the prevailing northerly currents. This causes an upwelling of more saline water on the Danish side. In Fig. 15 A one can see how the isohalines incline from west to east. The halocline is in this case found at its normal depth. An extreme example is given in Fig. 15 B, where the difference in salinity between the Danish and Swedish coasts amounts to 20 o/oo and the halocline is found at 7 - 10 m near the Swedish coast and at the surface about 3 km from the Swedish coast.

Long-term variation in salinity. The calculation of mean values for periods of more than one year at different depths and stations shows that there is a long-term variation in the salinity conditions in the investigated area (Fig. 16 A - C). At Svinbådan there is a slight increase in the salinity from 1923 to 1952 at 0, 5 and 10 m, while the increase at 14 m occurs earlier, in the years 1935 - 1939, and at 17 m is negligible. All depths but mostly the deeper layers show a decrease in salinity during the middle of the fifties followed by another maximum around the year 1960. At Lappegrund, not far from Svinbådan, there is during the middle of the sixties a minimum in salinity at 5, 10 and 15 m, followed by an increase in salinity. The fluctuation in salinity at Svinbådan-Lappegrund from 1923 to 1969 is smallest in the surface layers, about 1 - 2 o/oo, and largest, 4.5 - 7.5 o/oo, in the bottom layers. At Oskarsgrundet the salinity at 5 and 8 m is decreasing in the first period. During the years 1950 - 1952 the values are at all depths higher than 1923 - 1928, indicating a maximum in salinity during the same period as at Svinbådan. The picture during the fifties is also similar at the two stations. The variation in salinity is during the whole period at Oskarsgrundet only 1 - 2 o/oo. In the Baltic proper by Falsterbo Reef one can find the same tendency with a maximum 1950 - 1952 as at the other stations, but the second maximum is changed forward to 1962 - 1964. The whole period fluctuation at Falsterbo Reef is as low as 0.8 o/oo.

Table 2. Quartiles, quartile range and variation breadth of salinity in o/oo and skewness of salinity.
Calculated from Hydrographical Observations on Swedish Lightships and Oceanografiske Observationer fra Danske Fyrskibe og Kyststationer.

Station	Depth	q_1	q_2	q_3	$q_3 - q_1$	g_1	R
Kattegatt S 1967-69	0 m	15.85	18.27	21.35	5.50	0.17	22
	5 m	17.09	19.62	22.51	5.42	0.24	24
	10 m	20.09	23.19	25.71	5.62	0.50	20
	15 m	24.51	27.57	31.38	6.87	0.16	19
	20 m	29.31	31.89	33.69	4.38	-1.12	16
	25 m	30.97	32.73	34.10	3.13	-1.21	15
Number of ob- servations	0 m	270	540	810	540	1080	
Svinbådan 1958-60	0 m	10.67	13.37	17.29	6.62	0.45	21
	5 m	11.58	14.78	18.41	6.83	0.55	25
	10 m	15.50	19.13	22.20	6.90	0.66	24
	14 m	20.24	23.35	28.43	8.19	0.04	23
	17 m	25.59	29.97	31.67	6.08	-1.00	23
Number of ob- servations	0 m	243	487	729	486	973	
Lappegrund 1964-66	0 m	10.51	13.87	17.92	7.41	0.38	17
Number of ob- servations	0 m	262	524	785	523	1048	
Oskarsgrundet 1959-61	0 m	7.76	8.00	11.01	3.25	1.85	22
	2.5 m	7.79	8.48	11.16	3.37	1.87	24
	5 m	7.85	8.86	15.70	7.85	1.47	24
	8 m	7.91	9.22	17.64	9.73	0.88	25
Number of ob- servations	0 m	114	229	343	229	457	
Drogden 1968-69	0 m	7.92	8.56	10.25	2.33	2.31	19
Number of ob- servations	0 m	182	364	546	364	728	
Falsterbo Reef 1959-61	0 m	6.72	6.69	7.36	0.64	1.55	5
	5 m	6.76	7.07	7.36	0.60	1.64	5
	10 m	6.73	7.07	7.31	0.58	1.67	5
Number of ob- servations	0 m	50	100	150	100	200	

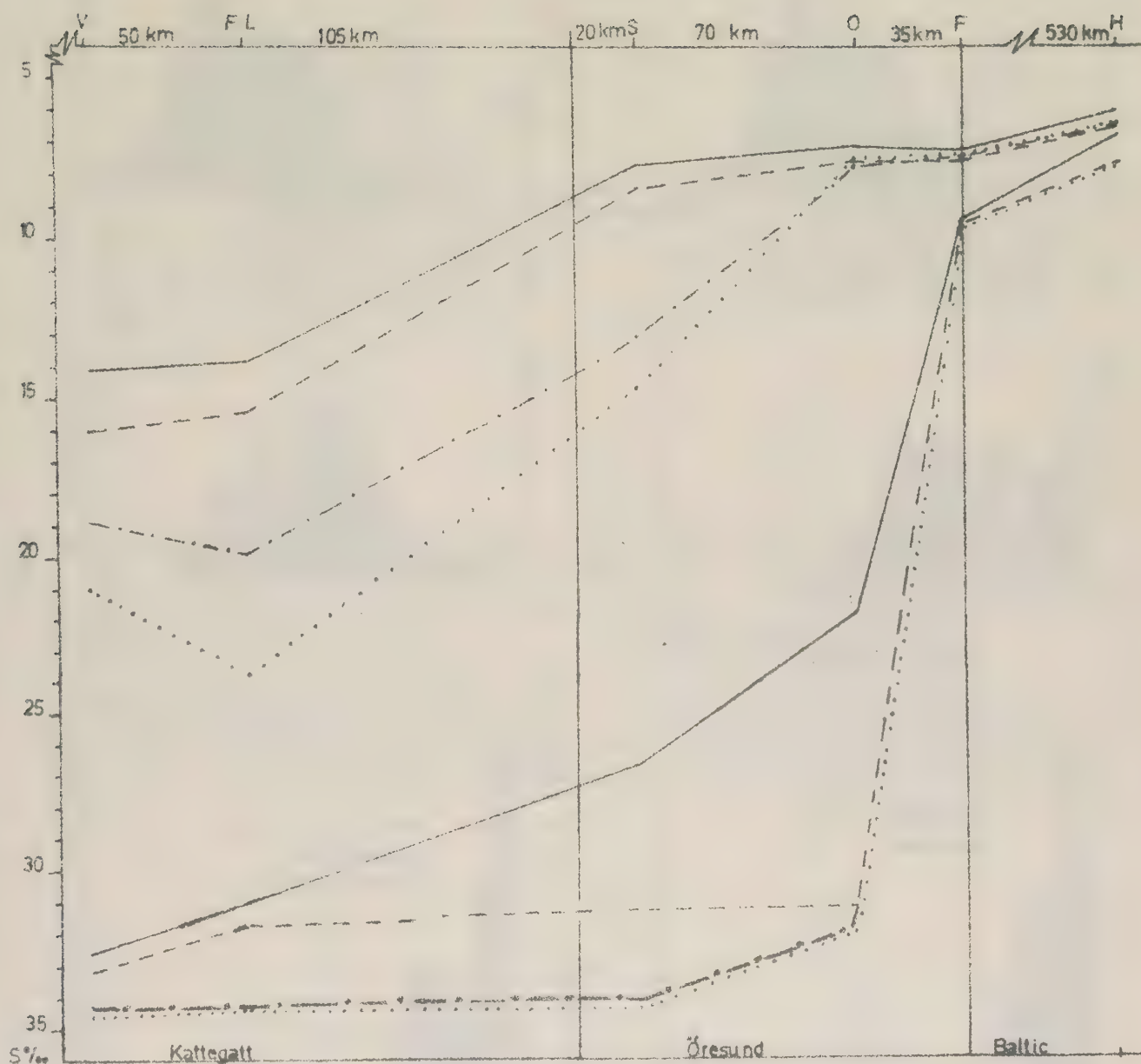


Fig. 8. The salinity amplitude (minimum and maximum values) at different depths along the southern Swedish coasts in 1959. Calculated from Hydrographical Observations on Swedish Lightships.

————	0 m	V Vinga	O Oskarsgrundet
- - - -	5 m	FL Fladen	F Falstehö Reef
- · - · -	15 m	S Svinbådan	H Hävringe
· · · · ·	20 m		

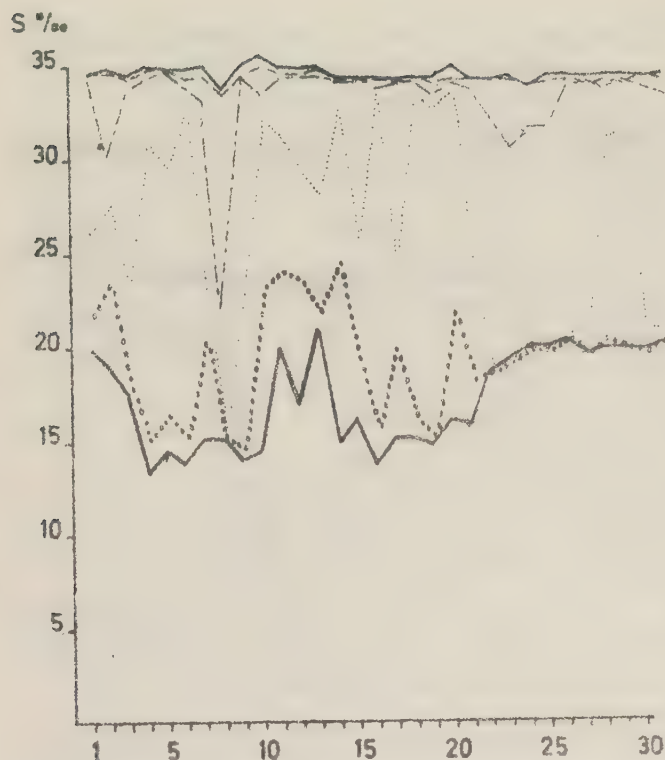


Fig. 9 A. Daily salinity at different depths at Kattegatt South during January 1969.

————— 25 m
 - - - - - 20 m
 - · - · - 15 m
 · · · · · 10 m
 ○ ○ ○ ○ ○ 5 m
 = = = = = 0 m

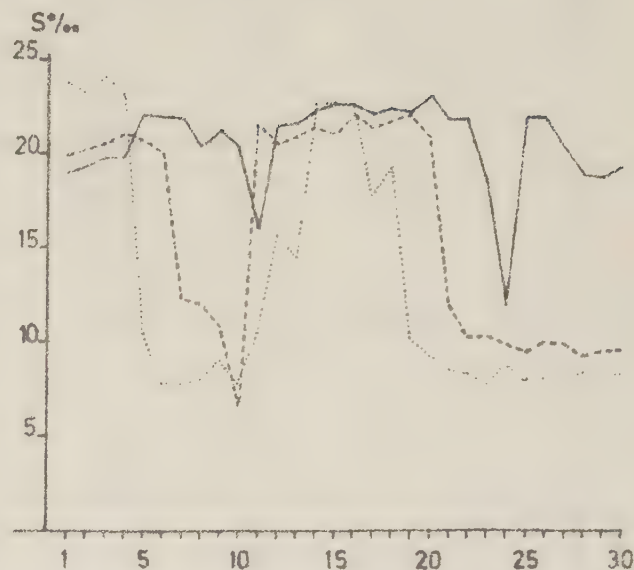
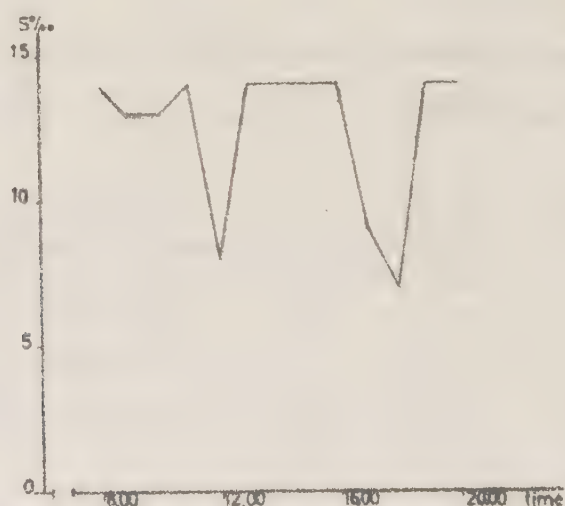


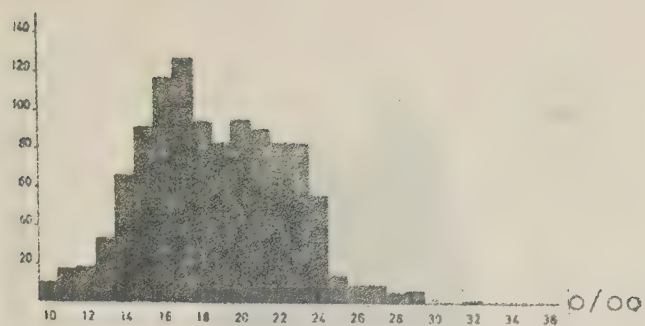
Fig. 9 B. Daily salinity at 0 m at different stations during April 1969.

Calculated from Hydrographical Observations on Swedish Lightships and Oceanografiske Observationer fra Danske Fyrskibe og Kyststationer.

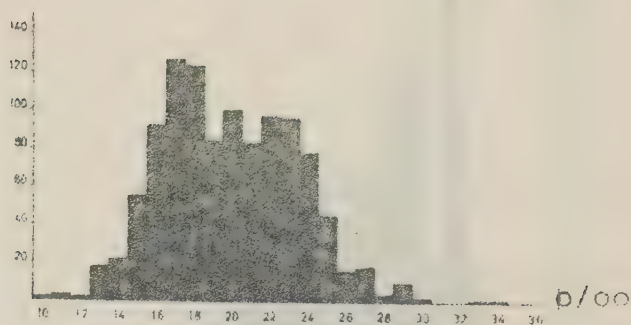
————— Kattegatt South
 - - - - - Lappegrund
 · · · · · Oskarsgrundet

Fig. 10. Hourly salinity at 0 m at Barsebäck 22/7 1971.

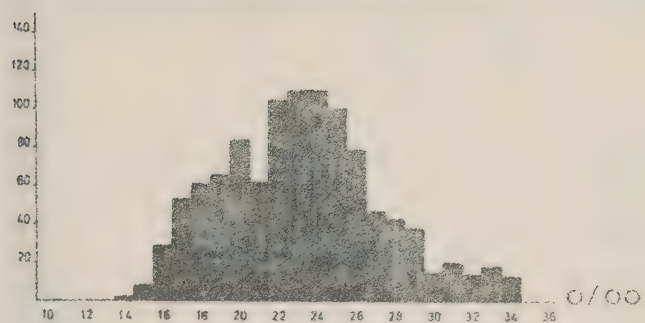




A 0 m



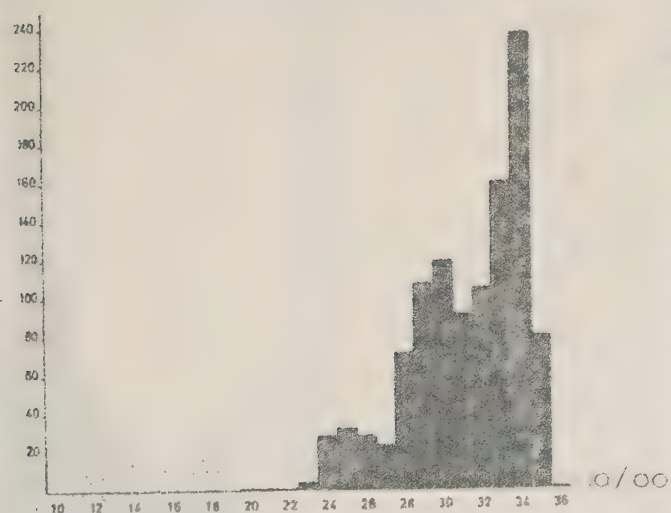
B 5 m



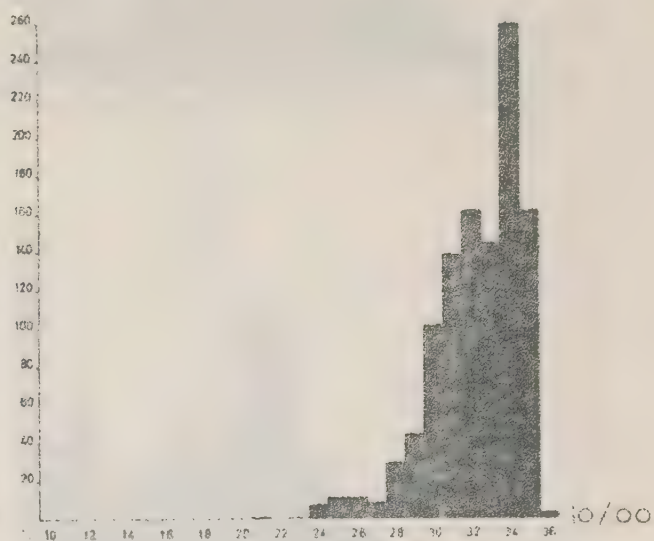
C 10 m



D 15 m



E 20 m



F 25 m

Fig.11 A-F. The frequency of days with different salinities during three years (1967-69) at Kattegatt South. Calculated from Oceanografiske Observationer fra Danske Fyrskibe og Kyststationer.

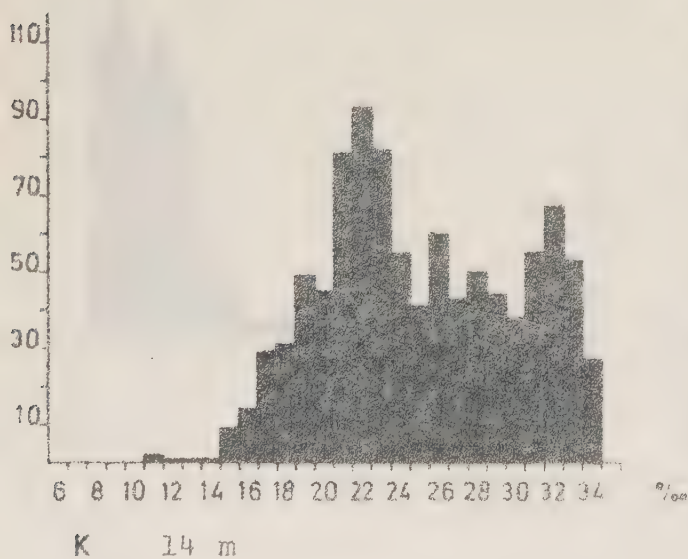
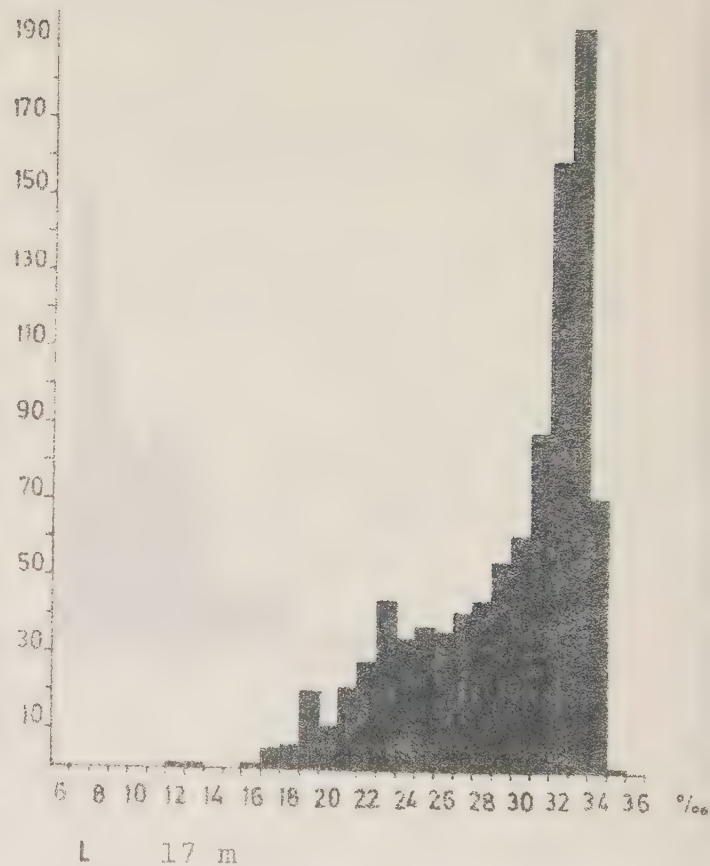
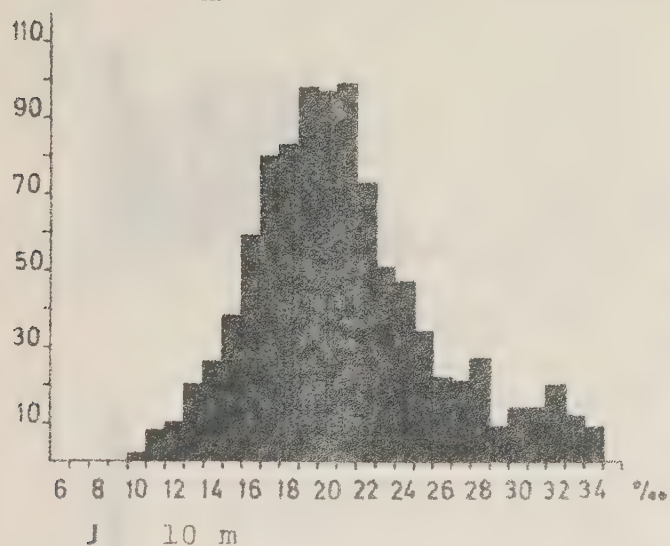
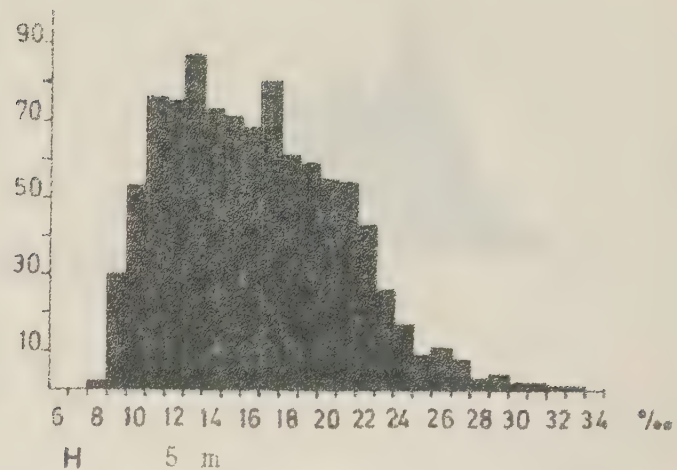
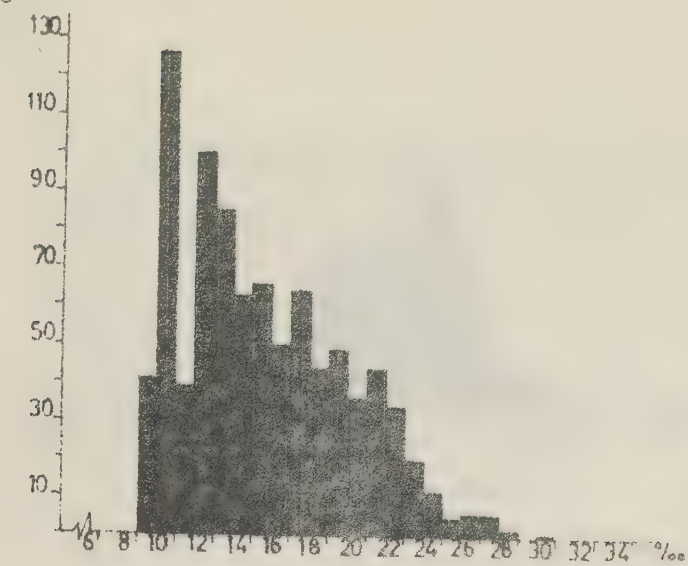


Fig.11 G-L. The frequency of days with different salinities during three years (1958-60) at Svinbådan.

Calculated from Hydrographical Observations on Swedish Lightships.

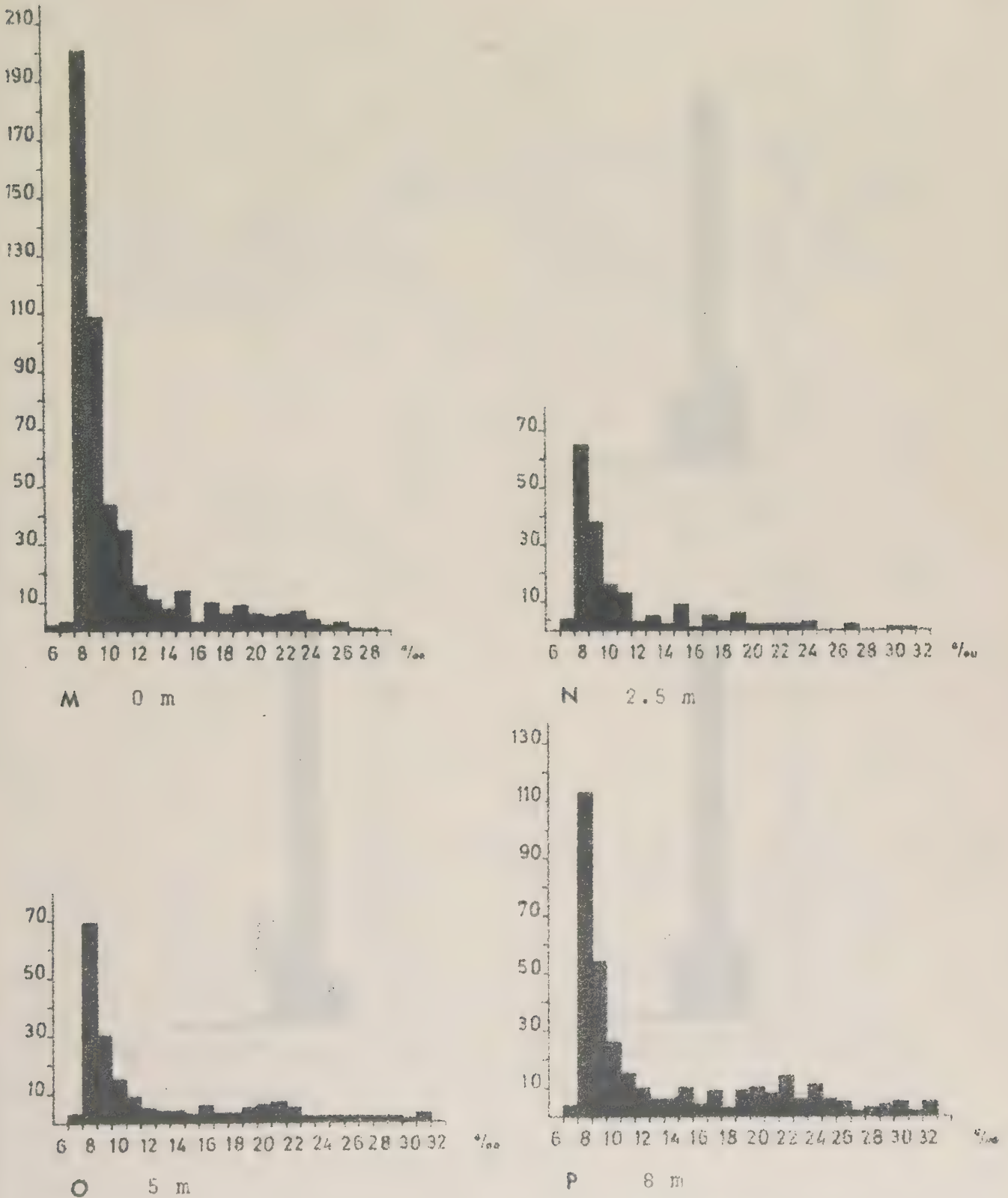


Fig.11 M-P. The frequency of days with different salinities during three years (1959-61) at Oskarsgrundet. Calculated from Hydrographical Observations on Swedish Lightships.

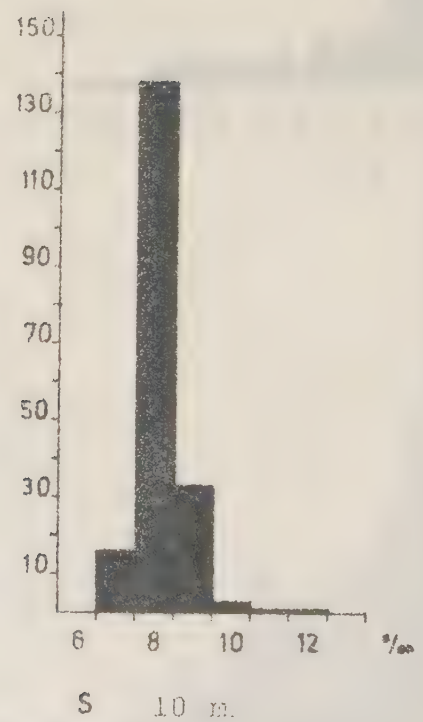
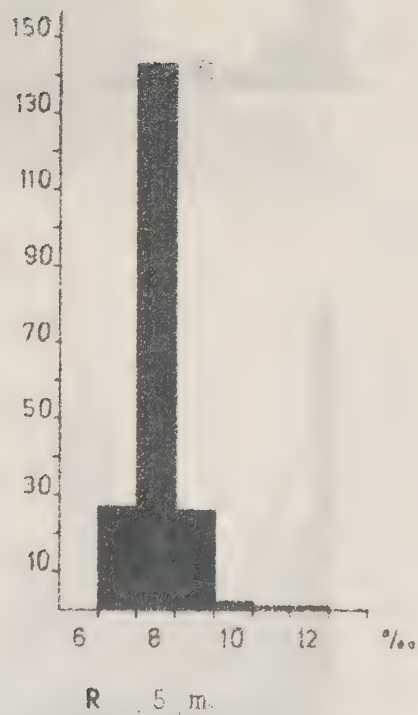
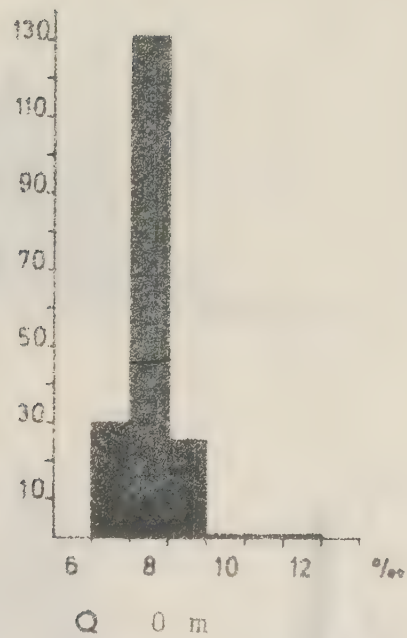
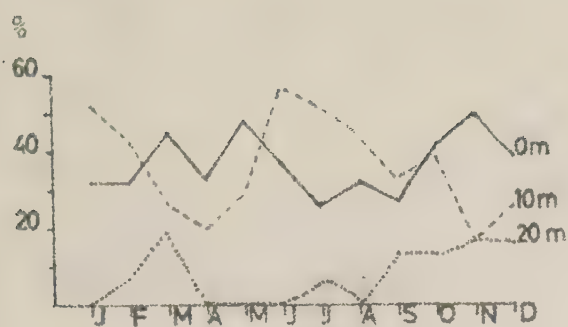
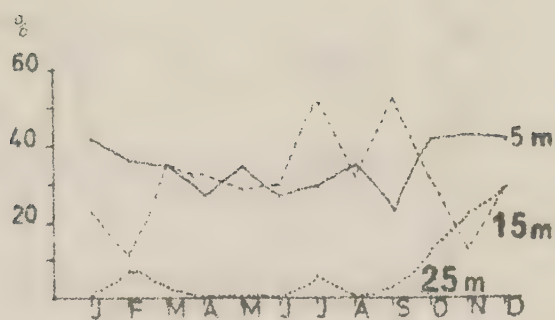


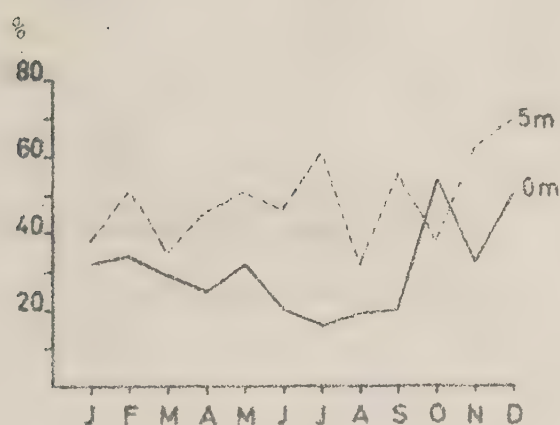
Fig. 11 Q-S. The frequency of days with different salinities during three years (1959-61) at Falsterbo reef. Calculated from Hydrographical Observations on Swedish Lightships.



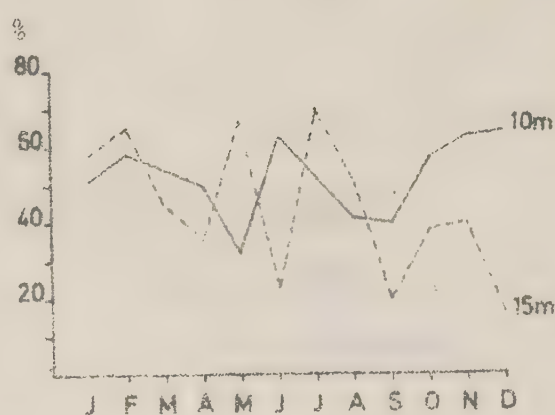
A Kattegatt South



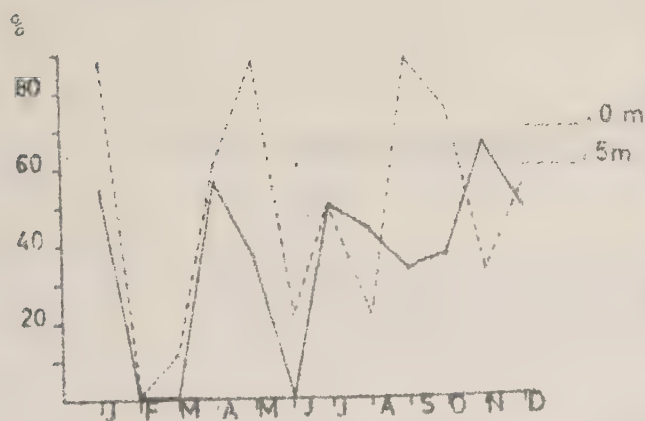
B Kattegatt South



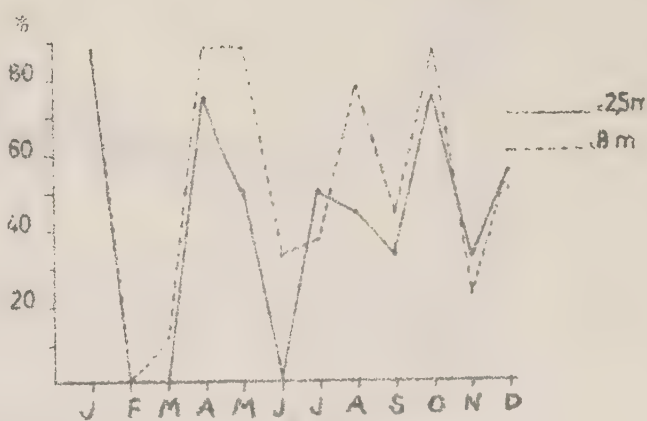
C Lappegrund



D Lappegrund



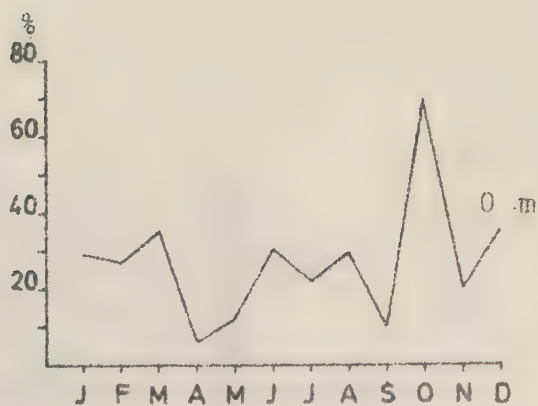
E Oskarsgrundet



F Oskarsgrundet

Fig.12 A-K. The percentage of changes in salinity from day to day exceeding 1.5 o/oo for different months, depths and stations.

Calculated from Hydrographical Observations on Swedish Lightships and Oceanografiske Observationer fra Danske Fyrskibe og Kyststationer.



G Drogden



H Falsterbo reef



J Falsterbo reef



K Falsterbo reef

Fig. 12 G-K.

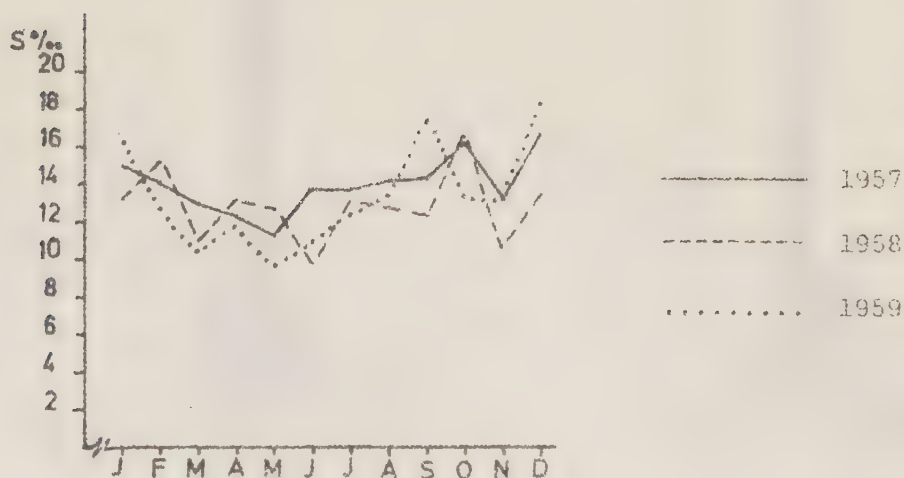


Fig. 13. Monthly mean salinity for the surface water at Lappegrund during 1957, 1958 and 1959.

Calculated from Nautisk - Meteorologisk Årbog.

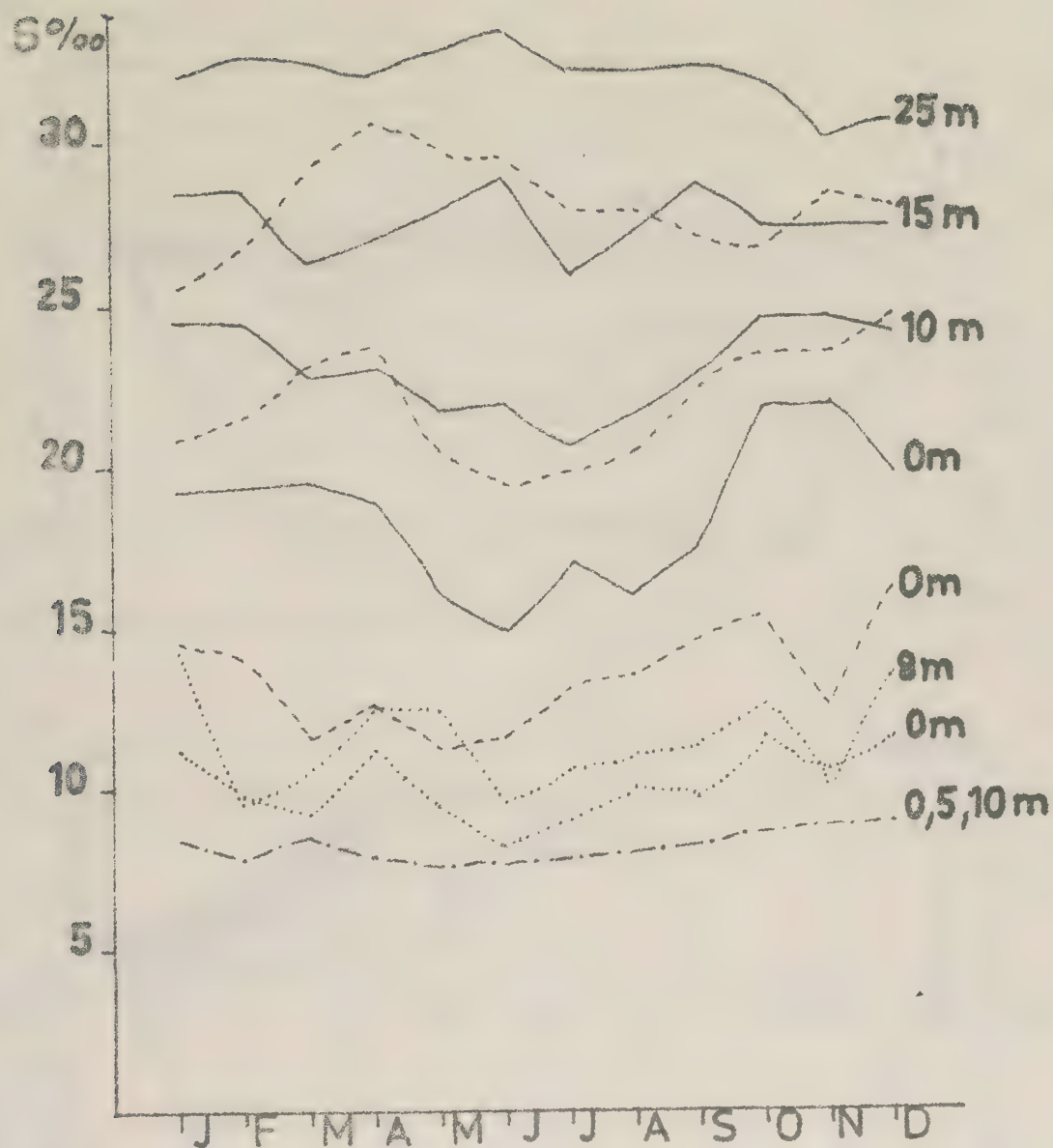


Fig. 14. Monthly mean salinity variation at different depths and stations. Calculated from Hydrographical Observations on Swedish lightships, Nautisk-Meteorologisk Årbog and Oceanografiske Observationer fra Danske Fyrskibe og Kyststationer.

- Kattegatt South 1967-69
- Lappegrund 1957-59
- Oskarsgrundet 1955-57
- . - . - Falsterbo Reef 1965-67

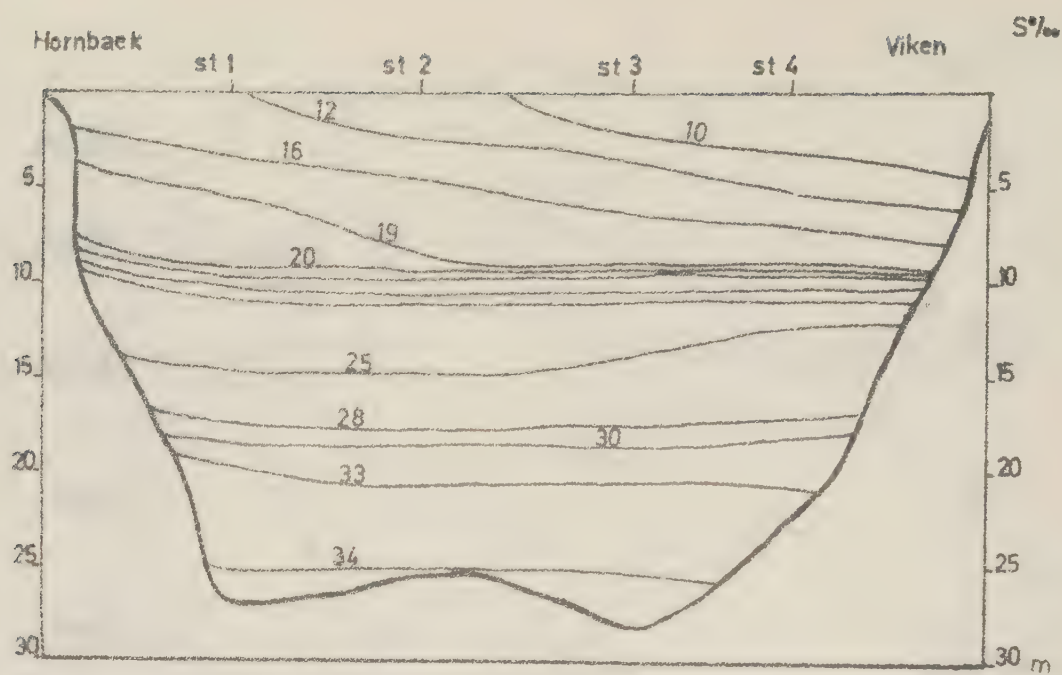


Fig. 15 A.

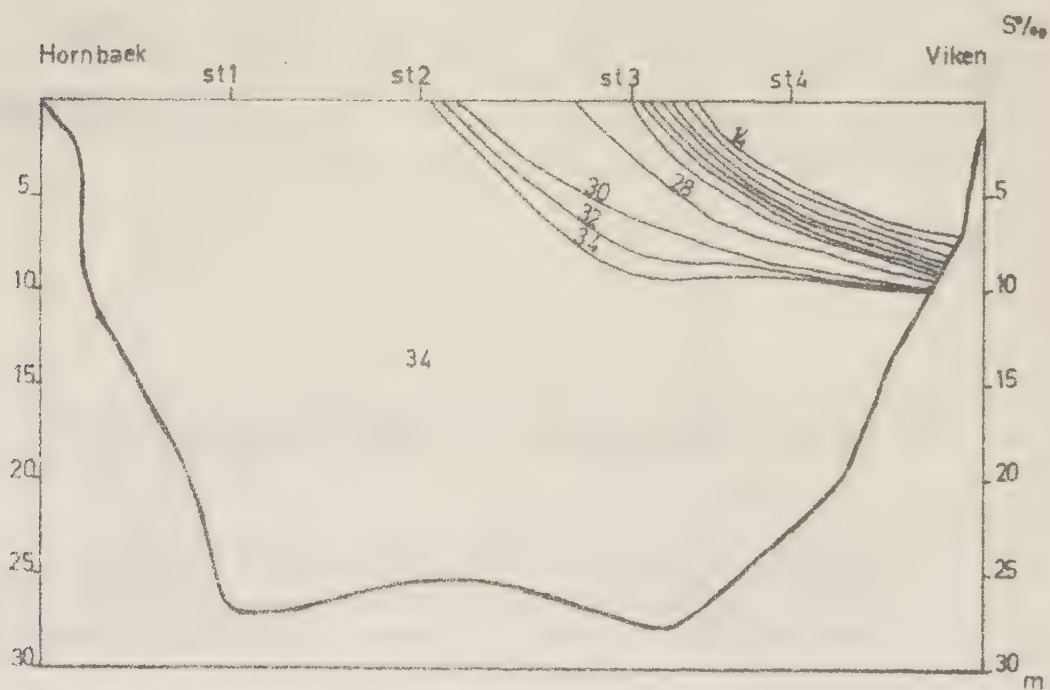


Fig. 15 B.

Fig. 15 A - B. Isohalines at a transect from Hornbaek to Viken (8.5 km) on two different occasions.

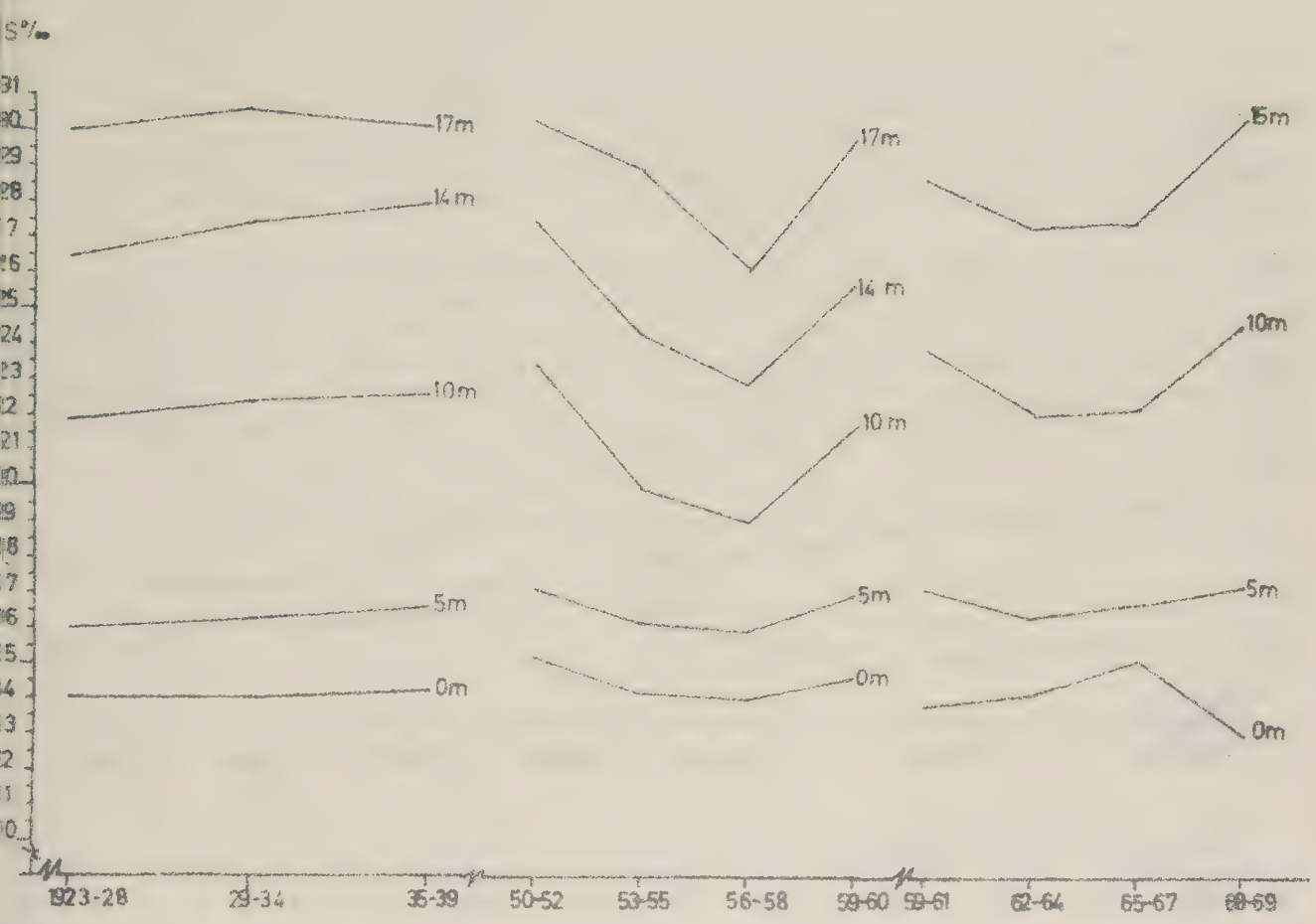


Fig. 15 A. Svinbådan 1923-60 and Lappegrund 1950-69.

Fig. 15 A - C. Long-term variation in annual mean salinity for the period 1923 - 1969 at different depths and stations. Calculated from Hydrographical Observations on Swedish Lightships, Monthly Average Values of Hydrographical Observations on Swedish Lightships, Nautisk-Meteorologisk Årbog and Oceanografiske Observationer fra Danske Fyrskibe og Kvaterationer.

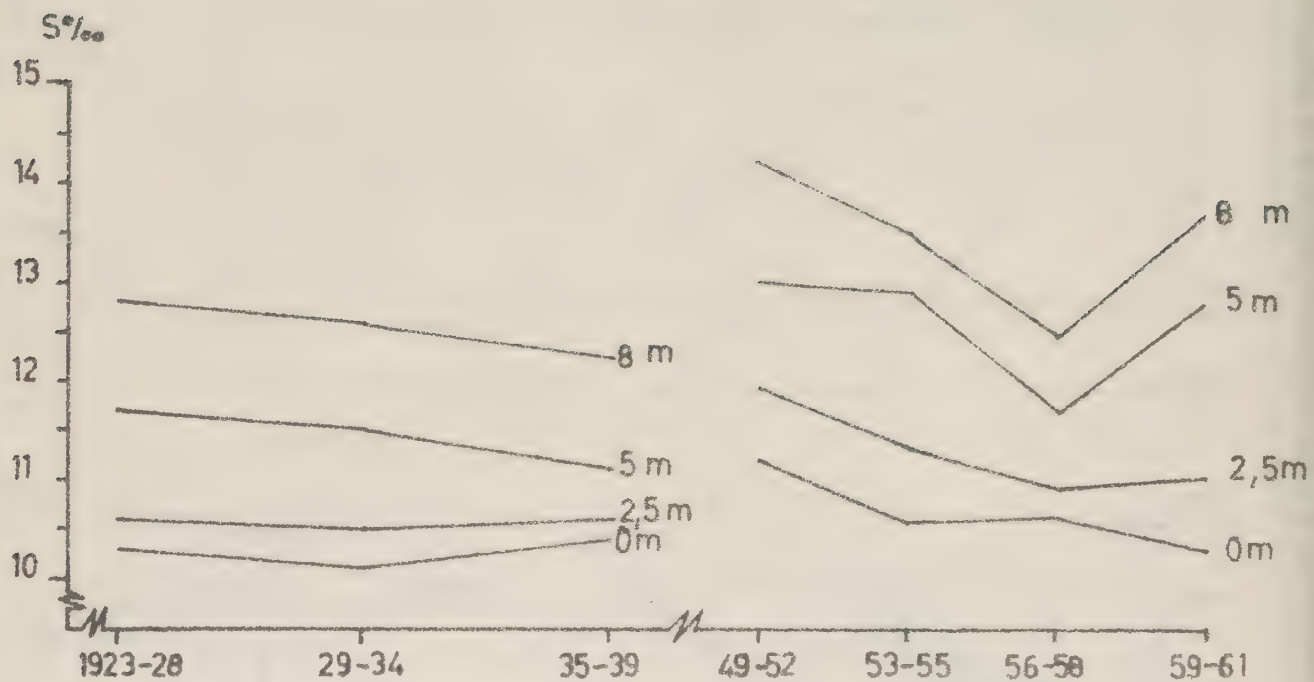


Fig. 16 B. Oskarsgrundet.

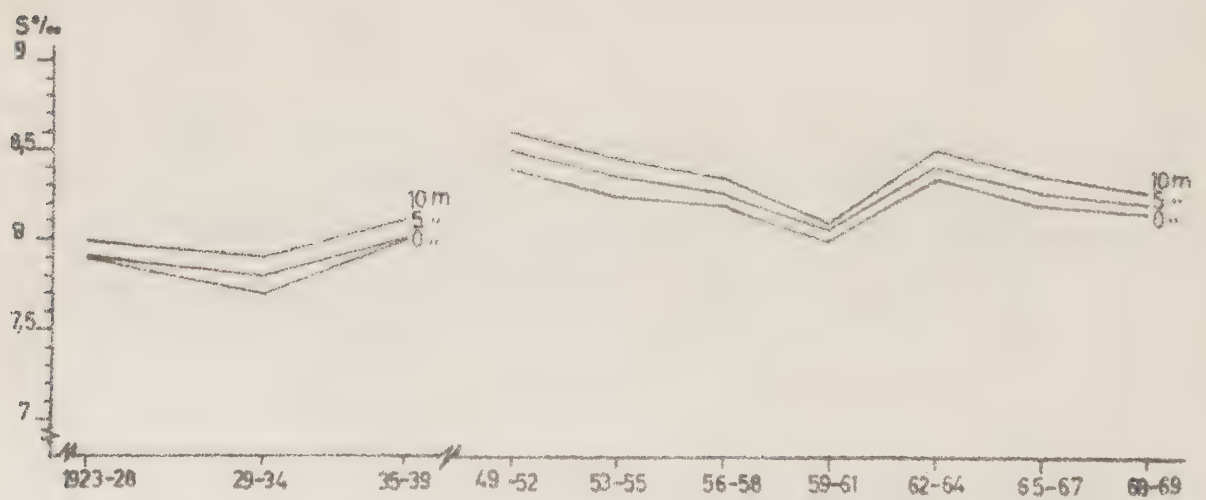


Fig. 16 C. Falsterbo Reef.

TEMPERATURE

The temperature at sea has been determined by two different methods:

1. A reversing mercury thermometer.
2. A thermistor in a Beckman RS 50 salinometer.

Since 1968 the water temperature at the surface at Kullen has also been recorded continuously twice a week by a mercury thermometer from the Swedish Institute of Hydrology and Meteorology (SMHI). All measurements have an accuracy of 0.01°C . The values have been used for the evaluation of the distribution of the species of algae. For the following analysis of the temperature conditions the data are mostly taken from the daily measurements on the Swedish and Danish lightships.

A comparison of annual mean temperatures for three years between the Kattegatt and Öresund areas is given in Table 3. The maximum amplitude is 1.31°C with the highest temperature at Lappegrund at 10 m and the lowest at Vinga at 30 m in depth. The maximum differences for different depths at the same station vary from 0.23 to 1.02°C with the lower values in the Öresund area. If the same depth at different stations is compared, one gets a variation range from 0.42 to 1.14°C .

Table 3. Annual mean values of water temperature ($^{\circ}\text{C}$) at different stations 1955-57.

Calculated from Hydrographical Observations on Swedish Lightships and Nautisk-Meteorologisk Årbog.

Station	0 m	5 m	10 m	15 m	20 m	30 m	Maximum difference
Vinga	9.27	9.25	9.82	8.96	8.70	8.29	0.98
Fladen	9.15	8.75	8.46	8.32	8.26	8.13	1.02
Anholt	9.38	9.40	9.22	9.03	9.22	8.55	0.85
Svinbådan	9.30	9.36	9.38	9.07 ¹			0.31
Lappegrund	9.37	9.44	9.60	9.42			0.23
Oskarsgrundet	8.95	8.47	8.46 ²			1 = 14 m 2 = 8 m	0.49
Maximum difference	0.43	0.97	1.14	1.10	0.96	0.42	

These values may give the impression that the temperature conditions are uniform along the Swedish west-coast. This is, however, not quite true.

When monthly mean temperatures for a 3-year period from different parts of the Swedish west-coast are compared (Table 4), one finds that the temperature in the surface is higher in the Öresund area than in Skagerrack and Kattegatt from November to April. The greatest difference is found between Bornö in the Gulimar Fjord and Falsterbo Reef from October to February. These differences are significant at the 0.01 % level. During summer the differences in temperature are small but the southernmost part of the Öresund has somewhat lower temperatures. Furthermore, the temperatures at 10 m in depth show no appreciable differences between the locations, possibly a trend towards a little higher values at Lappegrund. The bottom water (20 m in depth) on the other hand, is somewhat warmer in the Öresund than in Skagerrack and Kattegatt from January to April, at most 1.3°C (Jan.), and colder from May to November, at most 3.9°C (Sep.). This is shown in Fig. 17 too, where it is also noticeable that there is a time difference of about two months

for the occurrence of the maximum temperature in Kattegatt (Vinga) and the Öresund (Kattegatt South). The explanation of these phenomena is not clear.

The daily fluctuations of temperature are at all depths by no means as large as the salinity fluctuations. The surface water follows on the whole the air temperature, as can be seen in Fig. 18. The monthly temperature amplitude for the surface water is shown in Fig. 19. The fluctuations below 15 m can, however, be considerable in January - February and July - August (Fig. 20 A - D). The frequency of the number of days with a certain temperature at different depths and stations has been calculated in Fig. 21 A - R. It does not show a normal distribution but a varying grade of positive or negative skewness at different depths (Table 5). The skewness for the distribution of temperature classes is, however, not as pronounced as for salinity classes (cf. p. 21).

The monthly mean temperature varies slightly from year to year, exemplified for the surface water by Fig. 22. When comparing the monthly mean temperatures for a 3-year period (Fig. 23 A - E), it is obvious that in the whole area the water temperature at the surface and at 5 and 10 m in depth closely follows the air temperature except during January and February. The water from 15 to 25 m in depth, on the other hand, has a higher temperature than the surface water from November to March and a lower from April to September (~ October).

Long-term variation in temperature. Mean values of temperature for periods of more than one year are shown in Fig. 24. It is evident that there exists a considerable long-term fluctuation in temperature at all depths. There is from 1923 to 1939 an increase in temperature at Svinbådan at the surface and at 5 m of 0.8°C , at 10 m of 0.5°C and at 14 m of 0.2°C . During the period 1950 to 1958 there is a decreasing tendency to approximately the same values as for the beginning of the first period. The bottom water reaches a minimum in 1953-55. At the end of the 1960s the temperature at 0 - 14 m increases again by $0.8 - 1.2^{\circ}\text{C}$, at 18 m by only 0.4°C . From 1959 to 1967 the temperature decreases by approximately 0.8°C .

The periods with increasing temperature coincide with those of increasing salinity (cf. Fig. 16 A). This may depend on an increased frequency of south-going currents from Skagerrack and Kattegatt with a higher salinity and temperature in the Öresund area as a result (cf. Fig. 17).

Table 4. Monthly mean values of temperature ($^{\circ}\text{C}.$) during three years at different depths and stations along the Swedish west-coast.

Calculated from Hydrographical Observations on Swedish Lightships, Nautisk-Meteorologisk Årbog and Oceanografiske Observationer fra Danske Fyrskibe og Kyststationer.

0 m in depth	Bornö	Vinga	Kattegatt South	Lappe- grund	Oskars- grundet	Falsterbo Reef
Jan.	0.23	1.29	1.76	2.43	2.90	3.13
Feb.	0.53	1.03	1.06	1.33	1.63	2.00
Mar.	0.86	1.67	1.66	2.86	2.73	2.46
Apr.	4.23	4.35	4.86	5.50	4.96	4.50
May	9.76	9.40	9.26	10.23	9.26	8.40
Jun.	15.80	14.86	14.70	15.20	14.26	13.53
Jul.	17.53	16.60	16.70	16.80	16.03	15.56
Aug.	17.26	16.80	18.46	17.36	17.00	16.80
Sep.	14.76	14.60	16.56	15.23	15.20	15.10
Oct.	10.76	11.94	11.83	11.86	12.16	12.40
Nov.	6.30	7.25	8.23	8.16	8.50	8.73
Dec.	2.76	3.32	3.63	4.70	5.45	5.20
M	8.39	8.59	9.05	9.30	9.17	8.28
10 m in depth	Bornö	Vinga	Kattegatt South	Lappe- grund	Oskars- grundet	Falsterbo Reef
Jan.	3.60	3.52	3.23	4.26	3.60	2.93
Feb.	2.46	2.85	2.36	3.16	2.53	1.90
Mar.	2.00	2.18	2.00	4.03	3.10	2.40
Apr.	3.53	3.91	4.46	5.20	5.00	4.43
May	6.96	8.16	7.60	8.13	8.73	7.93
Jun.	12.63	12.96	11.36	13.46	13.66	12.96
Jul.	15.26	15.50	15.60	15.93	15.83	14.90
Aug.	16.06	16.40	17.10	16.43	16.76	16.26
Sep.	15.20	14.92	15.30	15.33	15.20	14.66
Oct.	12.66	12.82	11.83	12.73	12.40	12.33
Nov.	9.43	8.26	8.83	10.26	9.33	8.66
Dec.	6.33	5.33	5.23	6.50	6.35	5.20
M	8.84	8.90	8.74	9.61	9.37	8.67
20 m in depth	Bornö	Vinga	Kattegatt South			
Jan.	5.00	4.84	6.30			
Feb.	4.70	3.81	5.26			
Mar.	3.20	3.70	4.40			
Apr.	4.03	4.16	4.66			
May	5.43	6.20	5.40			
Jun.	8.46	9.13	6.16			
Jul.	12.26	13.50	9.23			
Aug.	13.70	15.70	10.40			
Sep.	14.33	14.84	10.43			
Oct.	13.10	13.17	11.50			
Nov.	11.03	10.08	9.96			
Dec.	8.33	6.68	7.50			
M	8.63	8.82	7.90			

M = Annual mean value Bornö, Vinga 1965-67 Kattegatt South 1967-69
 Lappegrund, Oskarsgrundet, Falsterbo Reef 1959-61

Table 5. Quartiles, quartile range and variation breadth of temperature in °C and skewness of temperature.
 Calculated from Hydrographical Observations on Swedish Lightships,
 Nautisk-Meteorologisk Årbog and Oceanografiske Observationer fra
 Danske Fyrskibe og Kyststationer.

Station	Depth	q_1	q_2	q_3	$q_3 - q_1$	s_1	R
Kattegatt S 1967-69	0 m	3.32	9.55	15.89	12.57	0.10	20
	5 m	3.50	9.40	15.67	12.17	0.17	21
	10 m	4.38	9.23	13.45	9.08	0.08	20
	15 m	5.15	7.73	12.05	6.90	0.26	20
	20 m	5.71	7.54	10.46	4.75	0.08	16
	25 m	6.13	7.53	9.87	3.74	0.47	13
	Number of ob- servations	0 m	269	538	808	1076	7
Lappegrund 1959-61	0 m	4.22	9.42	15.69	11.47	0.17	22
	5 m	4.69	9.59	15.74	11.05	-0.11	13
	10 m	5.53	10.06	14.94	9.41	0.07	20
	15 m	5.88	8.65	12.36	6.48	0.31	20
	Number of ob- servations	0 m	273	546	818	1092	
Oskarsgrundet 1959-61	0 m	4.69	9.71	15.06	10.37	0.05	20
	2.5 m	5.29	10.63	15.05	9.76	0.04	20
	5 m	4.84	9.41	14.63	9.79	0.03	20
	8 m	5.32	9.93	15.09	9.77	0.06	20
	Number of ob- servations	0 m	264	528	791	1056	
Falsterbo Reef 1959-61	0 m	4.12	9.04	14.55	10.43	0.23	22
	5 m	4.11	8.57	13.89	9.78	0.15	22
	10 m	4.17	8.70	14.16	9.99	0.14	22
	Number of ob- servations	0 m	291	581	872	1162	

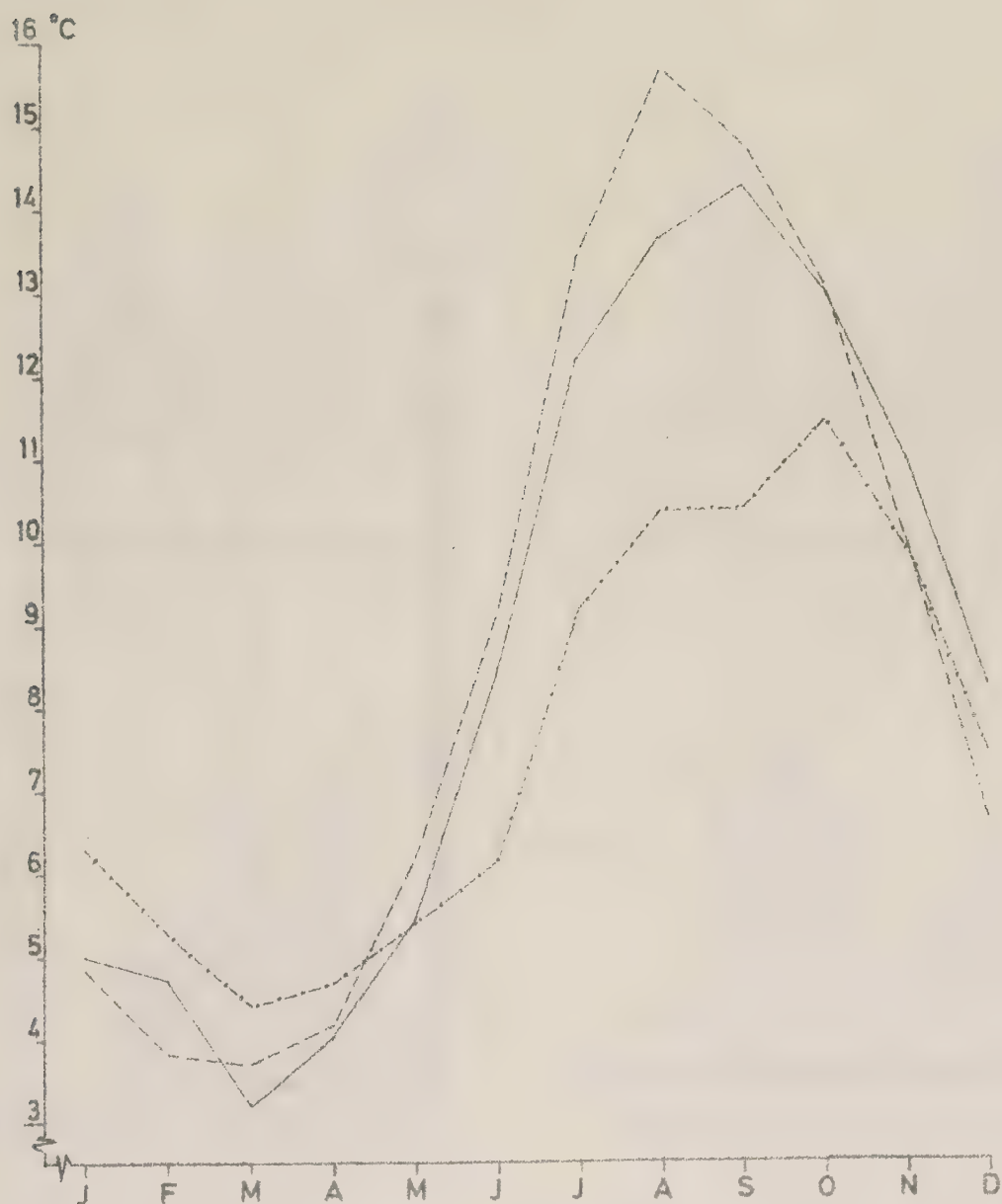


Fig. 17. Monthly mean temperature at 20 m in depth for three stations along the Swedish west-coast.
 Calculated from Hydrographical Observations on Swedish Lightships and Oceanografiske Observationer fra Danske Fyrskibe og Kyststationer.

———— Bornö 1965-67
 ----- Vinga 1965-67
 - · - · - · - · - Kattegatt South 1967-69

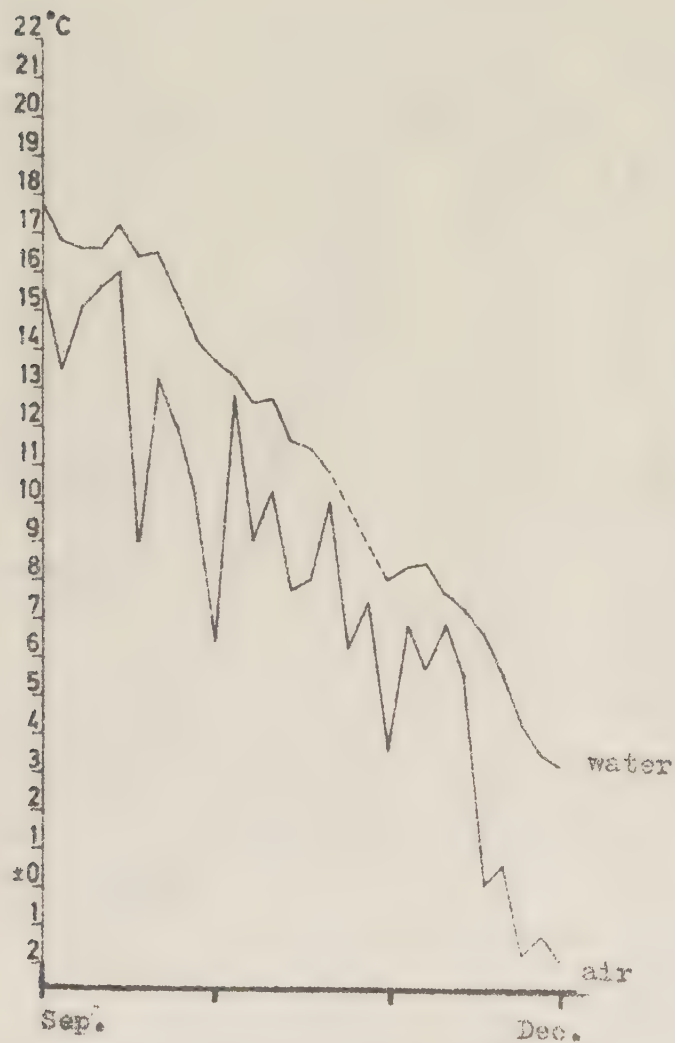


Fig. 18. Daily air and surface temperature at Kullen September - October 1969.

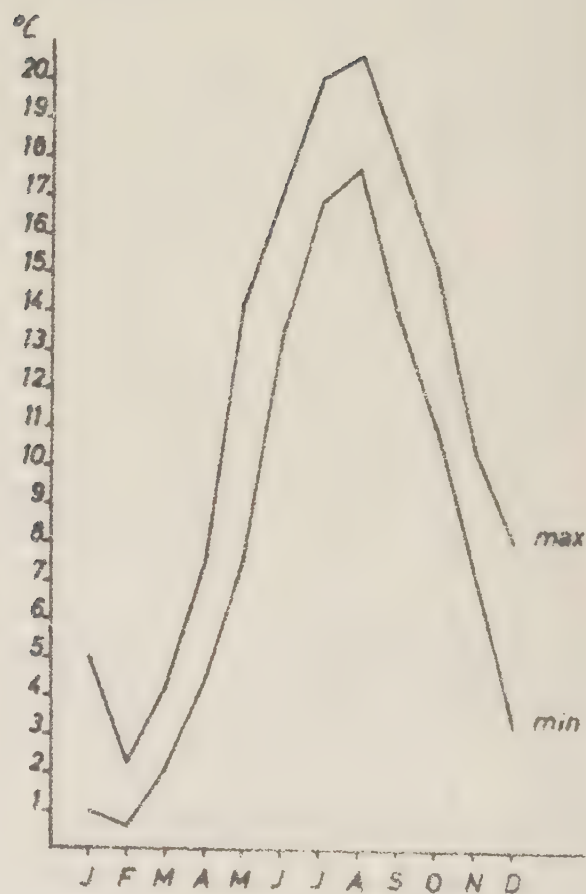
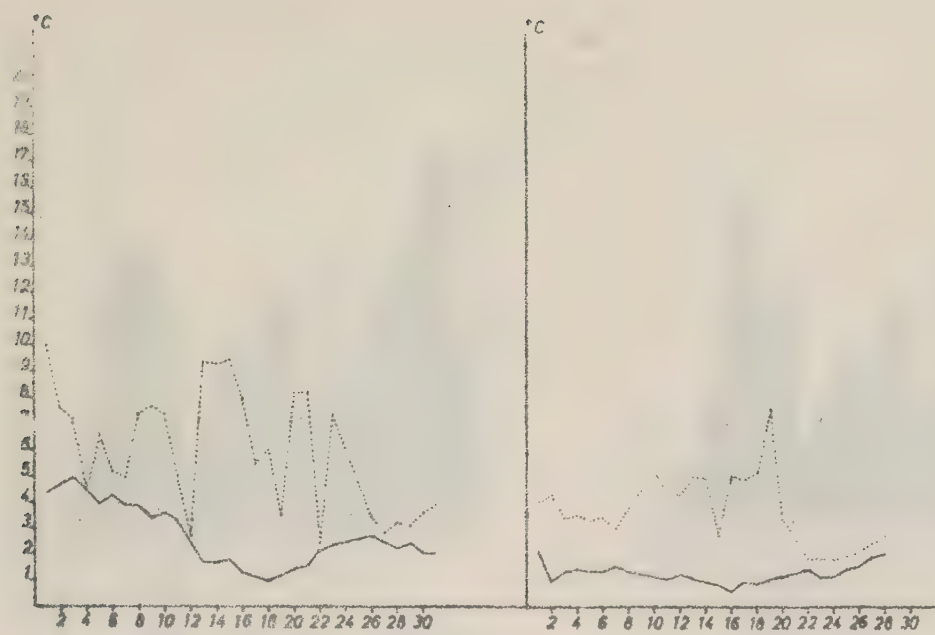


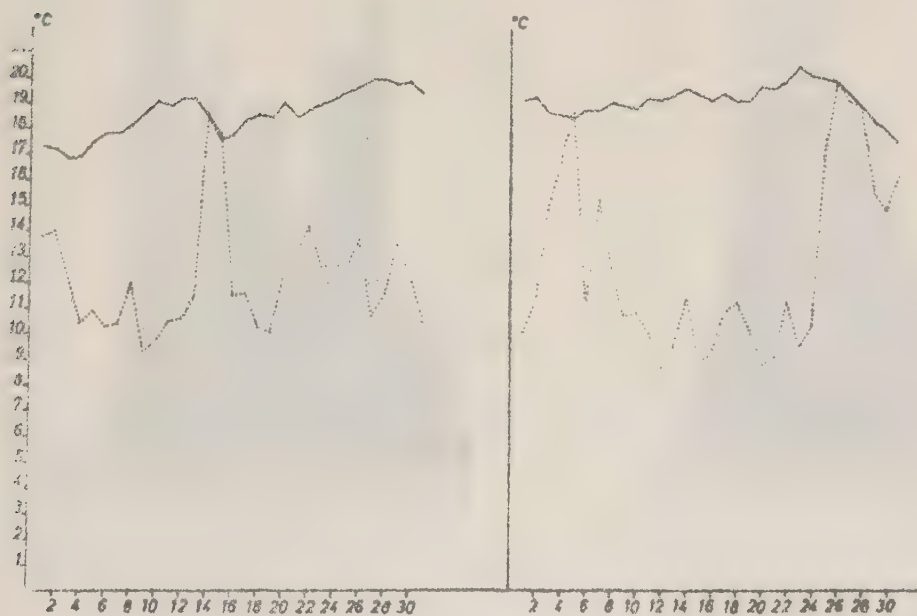
Fig. 19. Monthly maximum and minimum temperature for the surface water at Svinnökan 1959.

Calculated from Hydrographical Observations on Swedish Lightships.



A. January.

B. February.

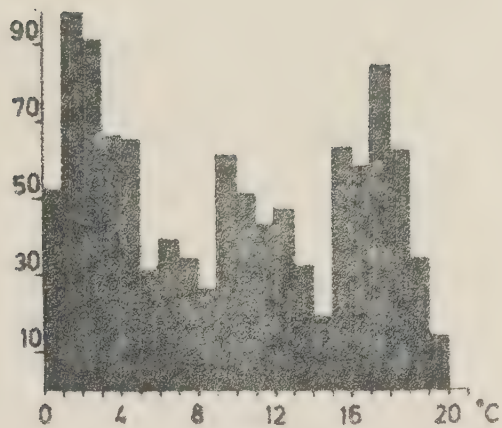


C. July.

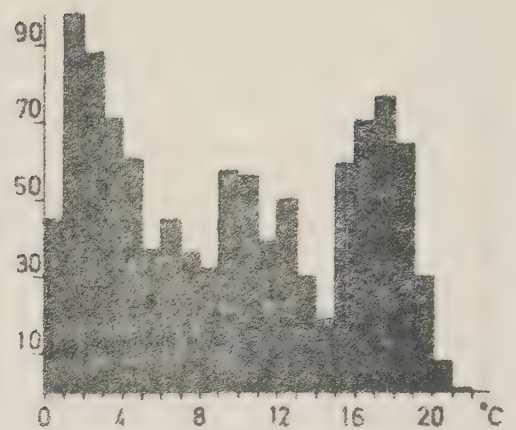
D. August.

Fig. 20 A - D. Daily temperature for the surface water and at 17 m in depth at Svinbådan during four months in 1959. Calculated from Hydrographical Observations on Swedish Lightships.

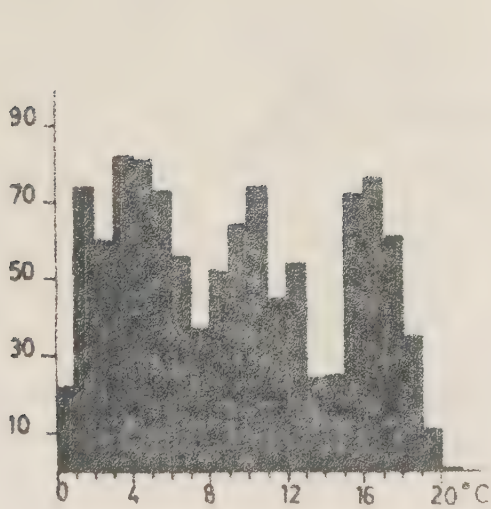
————— 0 m 17 m



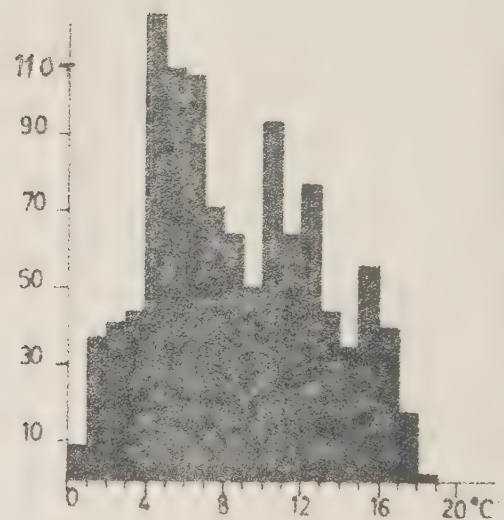
A. 0 m.



B. 5 m.

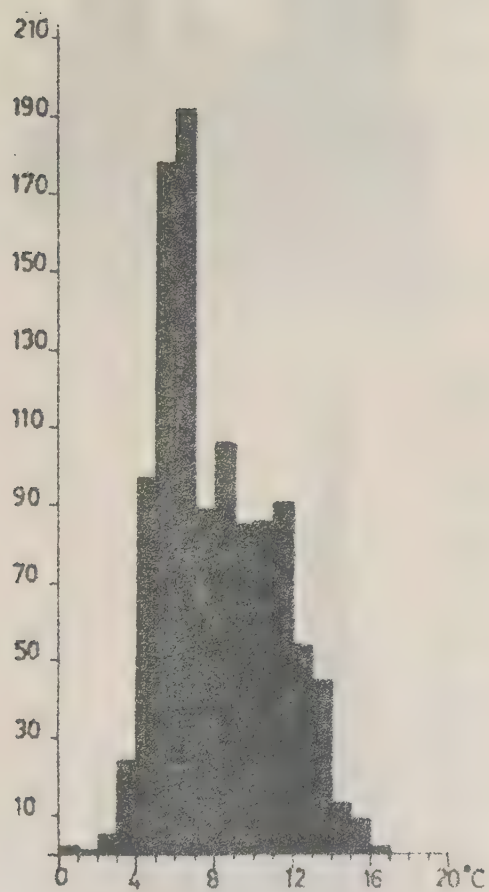


C. 10 m.

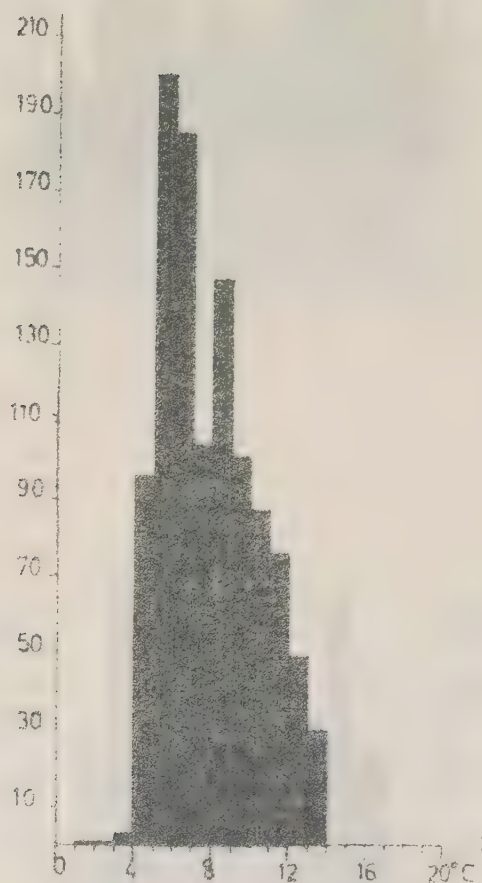


D. 15 m.

Fig. 21 A - F. The frequency of days with different temperatures at different depths at Kattegatt South 1967-69. Calculated from Oceanografiske Observationer fra Danske Fyrskibe og Kyststationer.



E. 20 m.



F. 25 m.

Fig. 21 E - F.

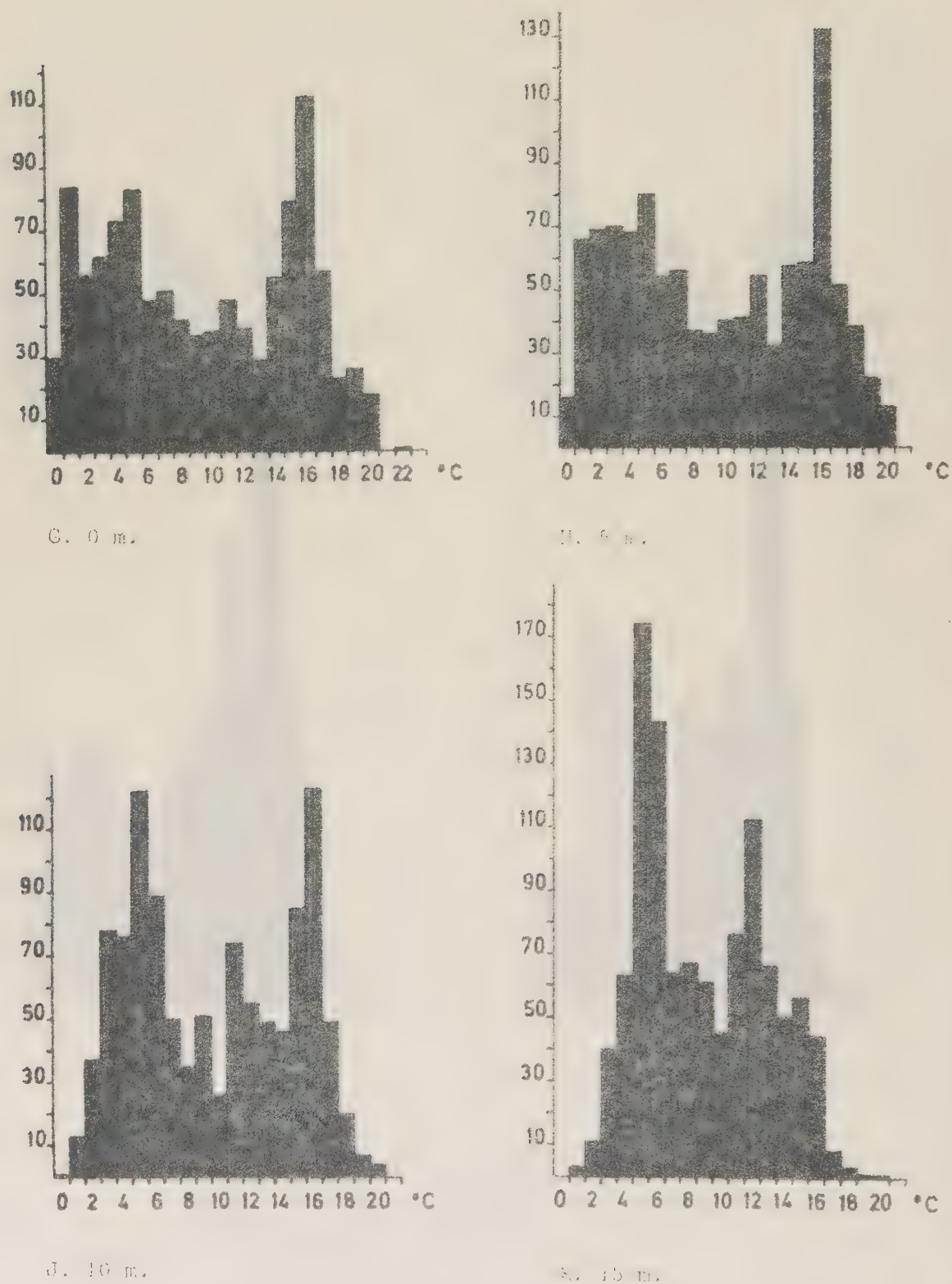
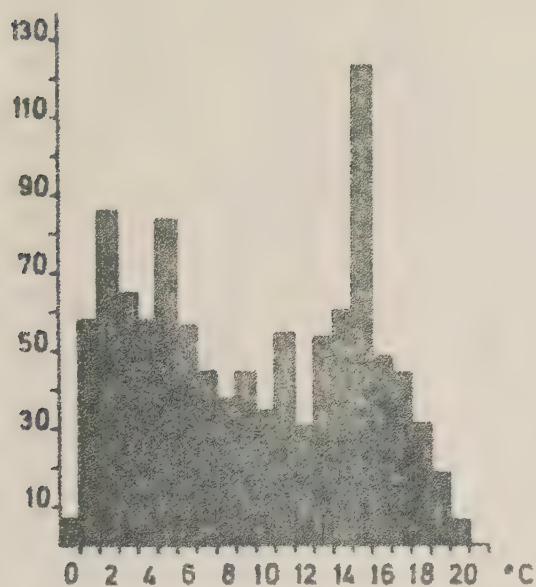
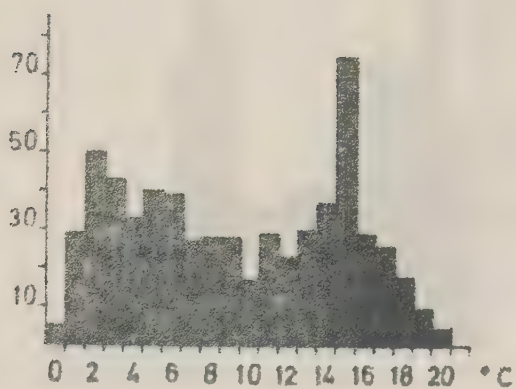


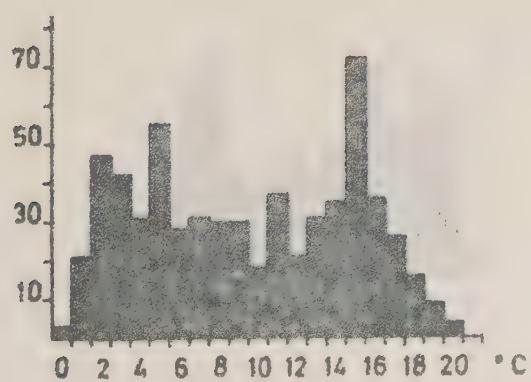
Fig. 21 G - K. The frequency of days with different temperatures at different depths at Lappegrund 1959-61. Calculated from Nautisk-Meteorologisk Årbog.



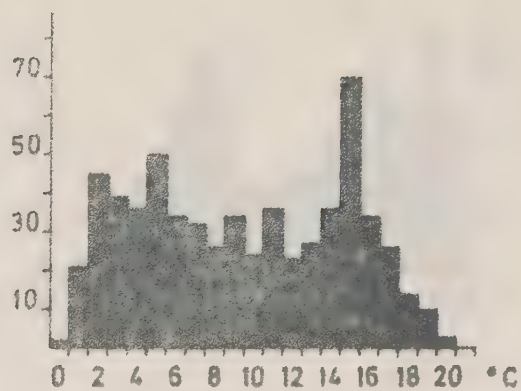
L. 0 m.



M. 2.5 m.

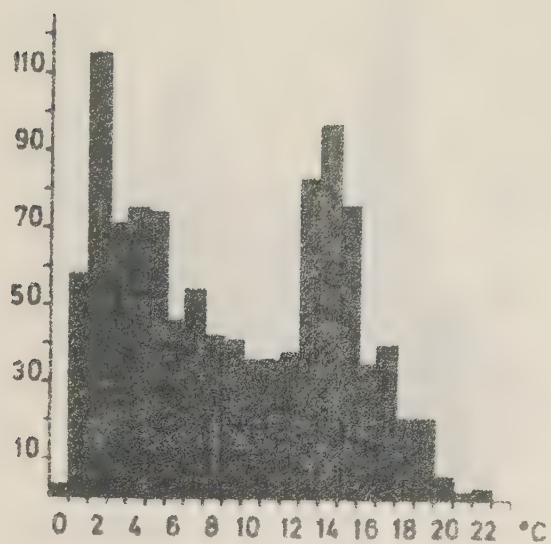


N. 5 m.

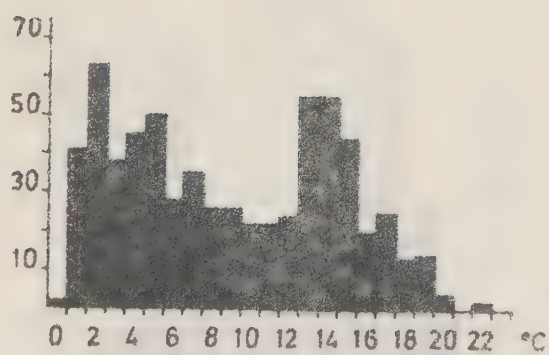


O. 8 m.

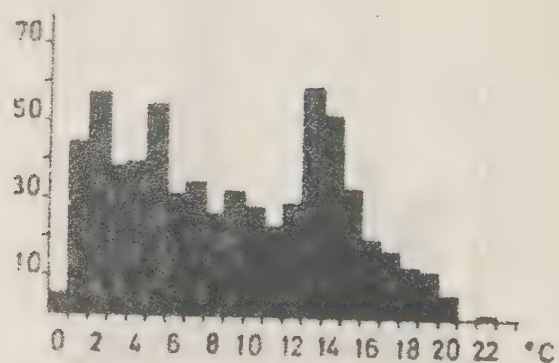
Fig. 21 L - O. The frequency of days with different temperatures at different depths at Oskarsgrundet 1959-61. Calculated from Hydrographical Observations on Swedish Lightships.



P. 0 m.

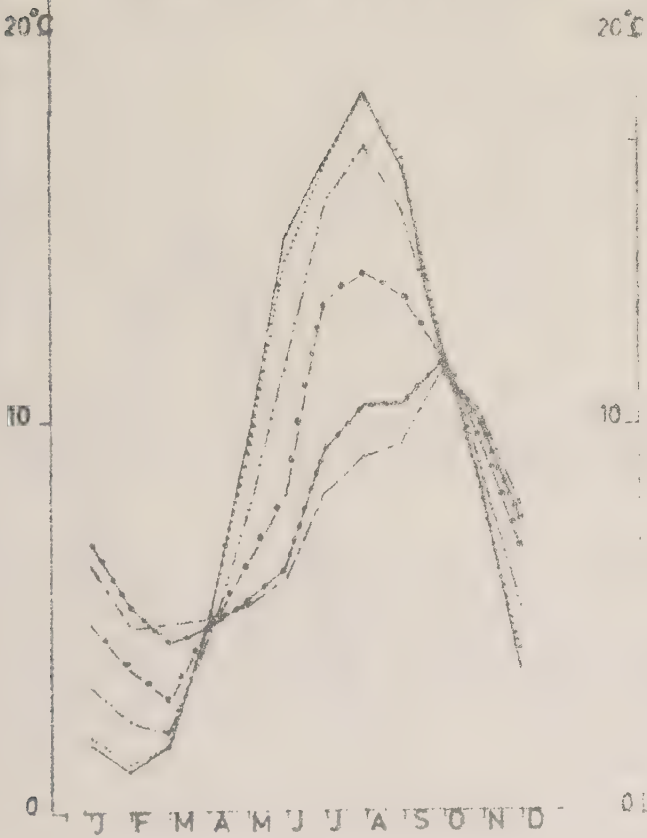
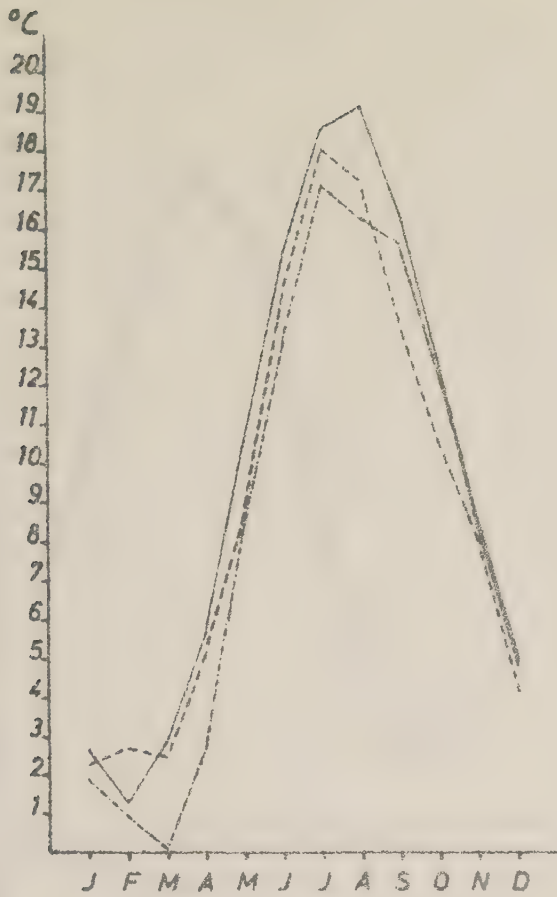


Q. 5 m.



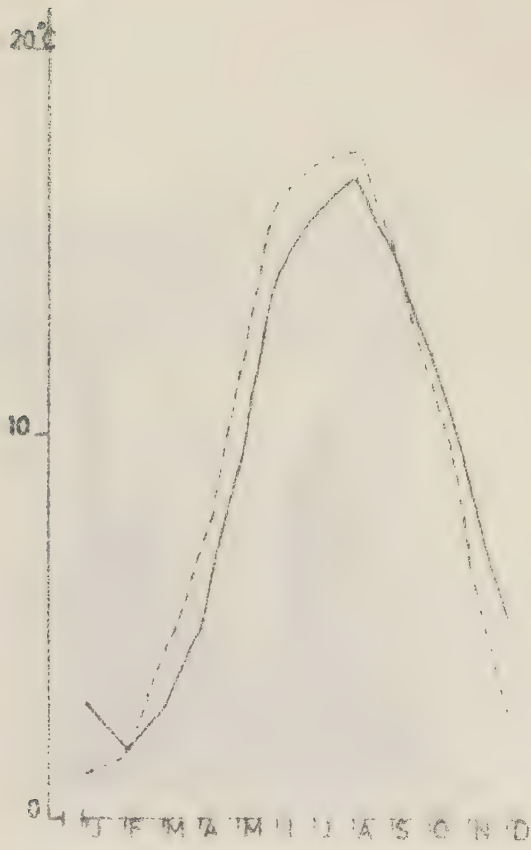
R. 10 m.

Fig. 21 P - R. The frequency of days with different temperatures at different depths at Falsterbo Reef 1959-61. Calculated from Hydrographical Observations on Swedish Light-ships.

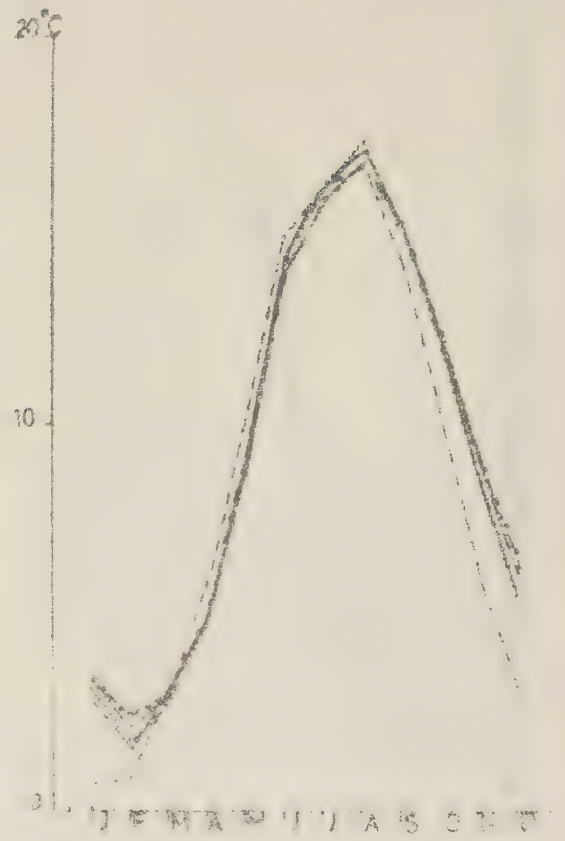


- - - air — 0 m · · · · · 5 m - - - - - 10 m - o - o - o - 15 m
 — · — · — · — 20 m — — — — — 25 m

Fig. 23 A - E. Monthly mean temperature during three years at different depths and stations. Calculated from Hydrographical Observations on Swedish Lightships, Nautisk-Meteorologisk Årbog and Oceanogr. Observ. fra Danske Lynskibe og Kyststationer.



1. Третьяков (1950-51).



2. Третьяков (1950-51).

Fig. 23 (continued). ————— 10°C
 ————— 15°C
 ————— 20°C
 ————— 25°C
 ————— 30°C



3. Гайстербо (1950-51).

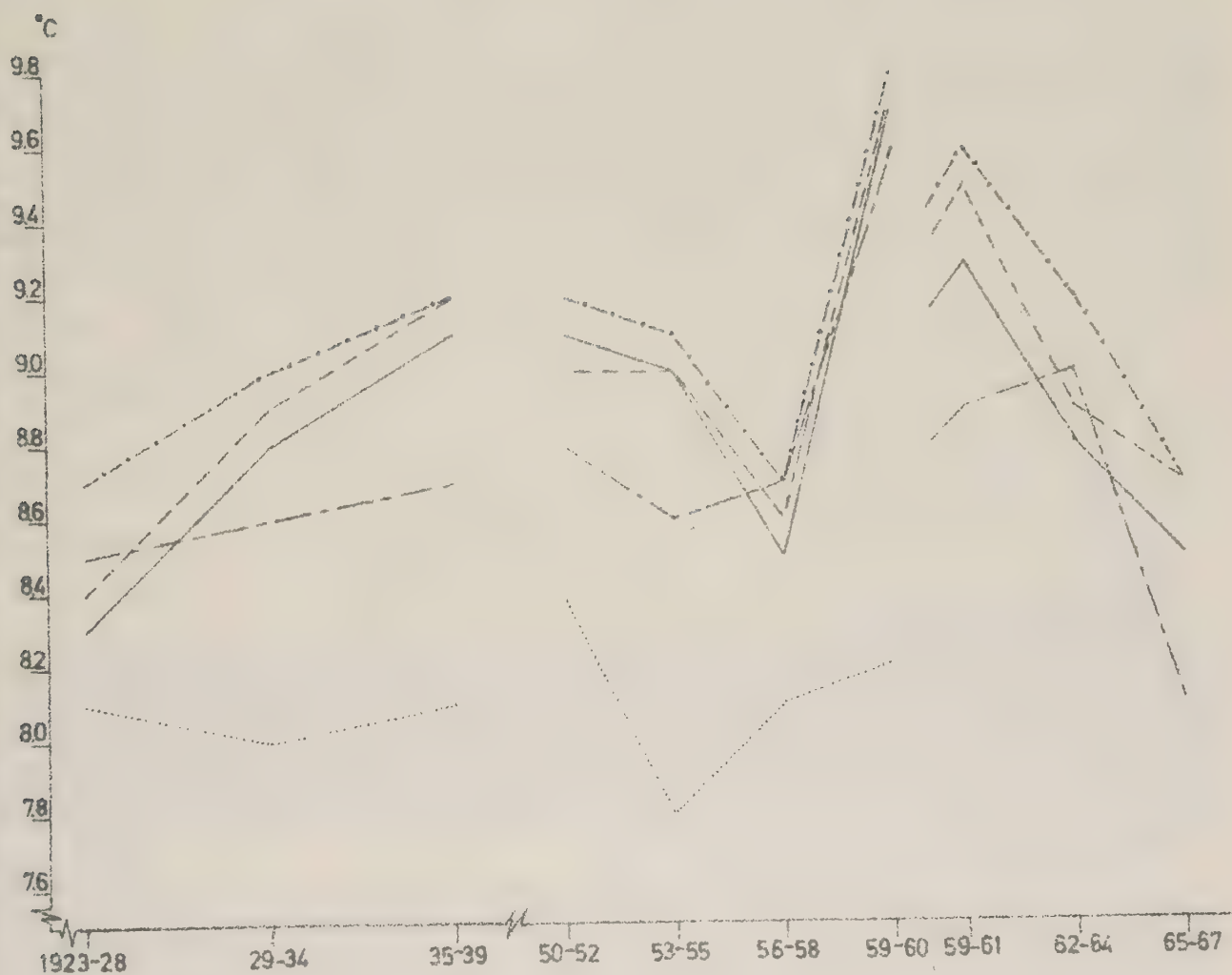


Fig. 24. Long-term variation in temperature at different depths at Svinhådan 1923-60 and Lappegrund 1959-67. Calculated from Hydrographical Observations on Swedish Lightships, Monthly Average Values of Hydrographical Observations on Swedish Lightships and Nautisk-Meteorologisk Årbog.

—————	0 m	— — — — —	14 m (at Lappegrund 15 m)
- - - - -	5 m		17 m
- . - . - .	10 m		

CURRENT CONDITIONS

There is quite a large material of current measurements for the Öresund, including surface measurements from Danish lightships by means of a drift-cross and measurements from various authors, such as Jacobsen (1925) and Dietrich (1951).

The author has made comparatively few measurements of the currents in the area. Two methods have been used:

1. A Braystoke current meter (the main method used).
2. An Ekman current meter.

A few measurements have been made in almost the whole Öresund area but the main part of the measurements have been undertaken on a transect between Hornbæk and Viken (cf. Fig. 4) in the north part of the area. Since January 1972 until March 1974 the currents have been measured every fortnight on this transect at four stations at each 5, 10, 15, 20 and 25 m in depth. These measurements are combined with measurements of other hydrographical parameters in order to make an estimate of the total flow of different elements to and out of the Öresund. This programme is carried out in conjunction with the Institute of Physical Oceanography, University of Copenhagen. The results will be dealt with in a later report.

An example of the variation of current conditions at one occasion in the north part of the Öresund is shown in Fig. 25.

Generally, it may be said that the current conditions in the Öresund are determined by the following factors:

1. The excess of fresh water in the Baltic.
2. The wind conditions over the North Sea and the Baltic. It is apparent that the winds in the peripheral areas have greater effect than local winds.
3. The changes in air pressure over the North Sea, Skagerrack, Kattegatt and the Baltic.
4. Differences in specific gravity of different water masses.
5. Topographical conditions.

The prevalent current in the surface is the north-going Baltic current (Fig. 26). At Drogden the main direction is NE, at Lappegründ NNW and at Kattegatt South NW. As a result of the north-going surface current there is a south-going bottom current with heavier, more saline water. Between these two layers is as a rule a marked halocline (cf. p. 19). However, as shown in Fig. 27, a south-going surface current also exists. The direction of this at Kattegatt South is WSW at Lappegründ SSE and at Drogden SW.

The frequencies of current directions in the surface during different years at Kattegatt South, Lappegründ and Drogden appear from Fig. 28 A - C. The distribution of the current directions during different months at the same stations and time periods (Fig. 29 A - C) reveals that the current situation in the surface is very variable, especially at Drogden.

According to Hermann (1967) the north-going surface current at Lappegründ is prevalent for 66 % of the year and the south-going for 34 %. At 15 m in depth there is a north-going current for 42 % of the time and a south-going for 58 %. The situation with south-going surface water and north-going deep-water occurs very seldom, 1 % of the year. At 23 m there is a north-going current for 24 % of the time and a south-going for 76 %. The current velocity in the surface varies between 0 and 200 cm/s, at 15 m somewhat lesser and at 23 m between 0 and 80 cm/s (Fig. 30).

The current situation is often more complex in shallow bays and near shore. As seen in Fig. 31 A - B from Lomma Bay, a local recirculation of the water can be generated with both south- and north-going surface currents in the Öresund. This phenomenon is apparently common in all the bays, including Kjöge Bay, Høllviken Bay, Salviken Bay, Lundåkra Bay, Nivå Bay and between Kullen and Mölle. It is probably responsible for the tremendous variation in trace elements, nutrient salts and yellow substance which is found in the Öresund. When the main current changes direction and the wind is south-westerly, the whole water mass of the bays can move almost undiluted along the coast.

WATER RENEWAL

The time for renewal of water at different depths in the Öresund has been calculated by Hermann (1967). The estimations were based on direct current measurements, the movement of salinity fronts through the Sound and for the deeper layer on a phase difference in the annual temperature cycles of the deep-water in Kattegatt and Öresund. The volume of the basin between Helsingør - Helsingborg and Malmö - Copenhagen was calculated as approximately 13 km³. The renewal times for the different water layers according to Hermann (loc.cit.) are shown in Table 6.

Table 6. Renewal times for different water layers in the Öresund.
Compiled from Hermann (1967).

Depth in m	Average renewal time in days
0 - 5	2 - 3
5 - 10	2 - 3
10 - 15	6
15 - 20	12
20 - 25	-
25 - 30	20 (10 - 40)

The times given for renewal of water are only valid for the water masses in the middle of the Sound. In shallow water near the shore and especially in the bays the renewal times may be very long. Calculations made by the present author by means of salinity changes and variations of the content of $P-PO_4$ and trace elements in the water, give a renewal time of the surface layer of about 4 days in Lomma Bay and 20 days in Lundåkra Bay.

WATER LEVEL

The changes in water level in the Öresund depend mostly on the wind and current conditions, and to a lesser extent on tidal phenomena. The tide in the Öresund is of two types. In the south part, where the difference between ebb and flood is approximately 7 cm, water level changes are generated by an internal tide system in the Baltic. In the central and north part of the Sound, the changes vary with the tide in Kattegatt and Skagerrack. According to Hilding (1948), the amplitude in the central part is approximately 10 cm and in the north part about 17 cm.

Measurements of water level have been made by two methods:

1. An Ott recording pegel (in Landskrona harbour).
2. A pegel observed every fourth hour by the harbour authority (in Helsingborg).

The measurements in Landskrona harbour show, as can be seen in Fig. 32, an approximate mean difference between ebb and flood of about 16 cm with extreme values varying from 8 to 20 cm.

The easily recognizeable changes in water level in the field are due to the wind and current conditions. These changes are of such an abundance and magnitude that they almost mask the tidal effects. Measurements from Helsingborg harbour, which could be representative for the whole area, give extreme values for a two-year period of 1.07 m below mean water level and 1.58 m over mean water level, a difference of 2.65 m. Of greater interest than the extreme high and low water levels are the normal high and low water levels (yearly mean

values of high and low water levels). At Helsingborg they are +0.85 and -0.68 m respectively, a difference of 1.53 m.

From a biological point of view, the fluctuation of the water level for shorter periods, e.g. one day or less, is of minor importance in the Öresund area. One has to bear in mind that the Öresund is one of the most heavily used seaways in the world with about 100 ships every 24 hours, which gives rise to a more or less continuous surge. There seems to be very little variation in the pattern of short-term water level fluctuations from month to month. Of major interest, however, is the long-term variation. In Fig. 33 the number of observations above and below the mean sea level, measured every fourth hour of the day during one year, are shown. The water level tends to be lower from January to June and higher levels are regularly found during the autumn from September to December. The monthly extreme values of high and low water level for two years are shown in Fig. 34, where the same tendency is evident. This situation with winter and spring low water and autumn high water is, according to Davidsson (1962), typical for large parts of western Europe and is generated by the general wind condition over the North Atlantic.

WIND CONDITIONS

The wind conditions of the Öresund area are, in spite of the small distance between the south and north border (about 140 km), rather complex in regard of wind force and direction. These problems have been penetrated earlier by Davidsson (1962). The present survey is based on meteorological measurements from the lightship Lappegrund between Helsingborg and Helsingör and daily radio report observations from Anholt (in the Kattegatt), Kullen, Helsingborg and Falsterbo.

In Fig. 35, the number of days with different wind directions at Lappegrund from 1957 to 1961 has been calculated. The figure shows that NW and W winds prevail from April to September and winds from E and SE dominate from January to April and from October to December. Winds from N and S are evenly distributed over the whole year, while SW winds prevail from October to January. Calm weather occurs during about 1 % of the whole year and in March, April and July up to 5 % of the time.

If the mean force during the year is studied (Fig. 36), it is found that there are no great monthly differences, the force varying from 2.5 to 3.3 Beaufort with the lower mean values from April to September and the higher for the period November to January.

In order to analyse the force of the wind in correlation to direction, the material from 1957 - 1961 was divided into four classes: ≥ 1 Bft, 1 - 3 Bft, 4 - 6 Bft and ≥ 7 Bft. The results are shown in Fig. 37 A - D. Of all winds with higher force than 1 Bft, winds from SE and SW dominate during the year with more than 40 % of the time. The most frequent wind forces are between 1 and 3 Bft and also in this class winds from SE and SW prevail. Wind forces between 4 and 6 Bft amount to a minor part of the year. Still winds from SE and SW dominate but also winds from W and NW are common. The total frequency of stronger winds, ≥ 7 Bft, is very low, only about 2 % of the year. This class dominates by winds from W and NW and to a lesser extent from SW, E and NE.

According to Davidsson (1962) and the present author's observations, the number of days with strong winds is higher in the north part of the Öresund area than in the south. Davidsson (loc.cit.) gives the following number of days per year with strong winds for the respective localities: Kullen 68, Helsingborg 65 and Skanör 54, a difference of 14 days. The author has found that with winds of e.g. 10 m/s at Kullen, as a rule the force is somewhat stronger at Hallands Väderö and a little lower at Helsingborg. A comparison of the difference in wind forces between different localities is shown in Table 7. In nearly 85 % of the time the difference is 0 - 6 m/s. The number of observations with the same wind force in the whole area is only 0.4 %. The same tendency is found when the difference in wind direction is compared at the different places (Table 8). In only

11.7 % of the time is the wind direction the same in the whole area. In the majority of the time the difference varies from 0 to 45° and differences from 45 to 90° are found in 13.4 % of the time.

Table 7. Comparison of the difference in wind force between Anholt N, Kullen, Helsingborg and Falsterbo.
Calculated from the daily radio weather observations.

Percentage of days with the same wind force in the whole area	0.4
Percentage of days with a difference of 0 - 3 m/s	35.3
Percentage of days with a difference of 3 - 6 m/s	49.1
Percentage of days with a difference of more than 6 m/s	15.2

Table 8. Comparison of the difference in wind direction between Anholt N, Kullen, Helsingborg and Falsterbo.
Calculated from the daily radio weather observations.

Percentage of days with the same wind direction in the whole area	11.7
Percentage of days with a difference of up to 45°	74.9
Percentage of days with a difference of 45° - 90°	13.4

WAVE ACTION

The generation of waves in a certain area depends on wind force, duration of the wind, fetch area and depth. The waves in the Öresund are in almost all cases wind waves. Swell occurs now and then in the north and south entrance of the area. However, waves do not always reach the possible maximum height owing to different directions of waves and currents.

Wave height has been measured at Kullen by means of a vertical pole, anchored at 20 m in depth, and site marks for every 50 cm at the top. The values were read by means of field glasses. These measurements have been checked against the diagrams of Bretschneider (1951), which give about the same values.

The fetch for different localities in the Öresund are, calculated according to Thorndike (1954), and the wave height, calculated according to Bretschneider (loc.cit.), are given in Table 9. The author has also tried to calculate the wave height according to a formula, given by Sørensen (1961). This formula was especially designed for wave height calculation in the Baltic. In the Öresund, however, it gives too high values to be useful.

Table 9. The wave height at 13 - 15 m/s at different localities in relation to wind direction and fetch.

Locality	Wind direction	Fetch	Wave height	Locality	Wind direction	Fetch	Wave height
Kullen	NNW - NW	300 km	3.8 m	Rarnebäck	NNW - NW	30 km	1.0 m
	NW - WNW	300 km	3.6 m		NW - W	20 km	1.5 m
	WNW - W	130 km	3.0 m		W - SW	30 km	1.4 m
Helsingborg	NW - W	150 km	1.1 m	Helsingborg	SW - S	40 km	1.4 m
	W - SSW	50 km	1.1 m		NW - W	20 km	1.7 m
	SSW - S	20 km	1.0 m		W - SW	30 km	2.0 m
					SW - S	40 km	1.4 m

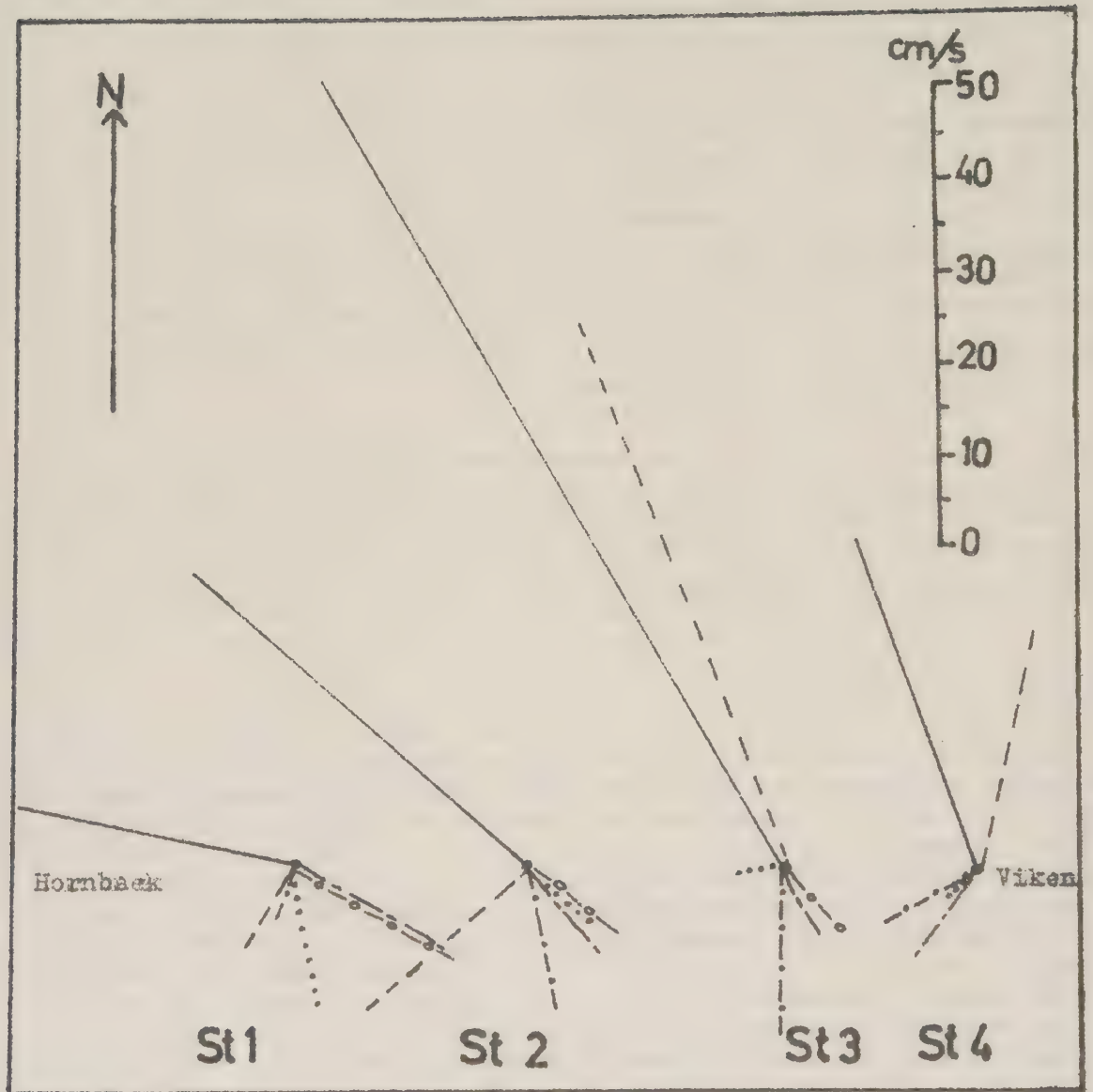


Fig. 25. The current conditions at four stations along a hydrographical transect from Hornbaek to Viken (8.5 km) 10 a.m. - 2 p.m. 11/10 1972. The lines indicate the current direction and force at different depths.

————— 0 m - - - - - 5 m - · - · - · - 10 m
 · · · · · 15 m - - - - - 20 m - o - o - 25 m



Fig. 26. The route of the northward surface current in the Öresund.
From The Danish Isotope Centre (1963).



Fig. 27. The route of the southward surface current in the Öresund.

From The Danish Isotope Centre (1963).

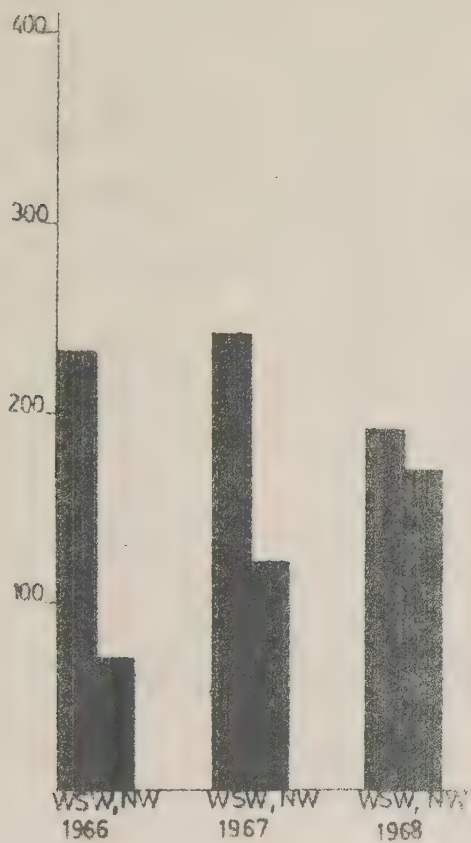


Fig. 28 A. Kattegatt South

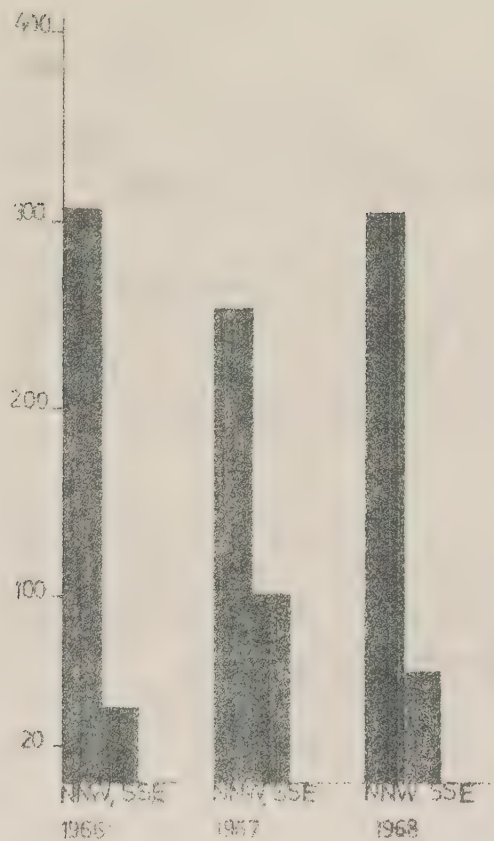


Fig. 28 B. Lappegrund.

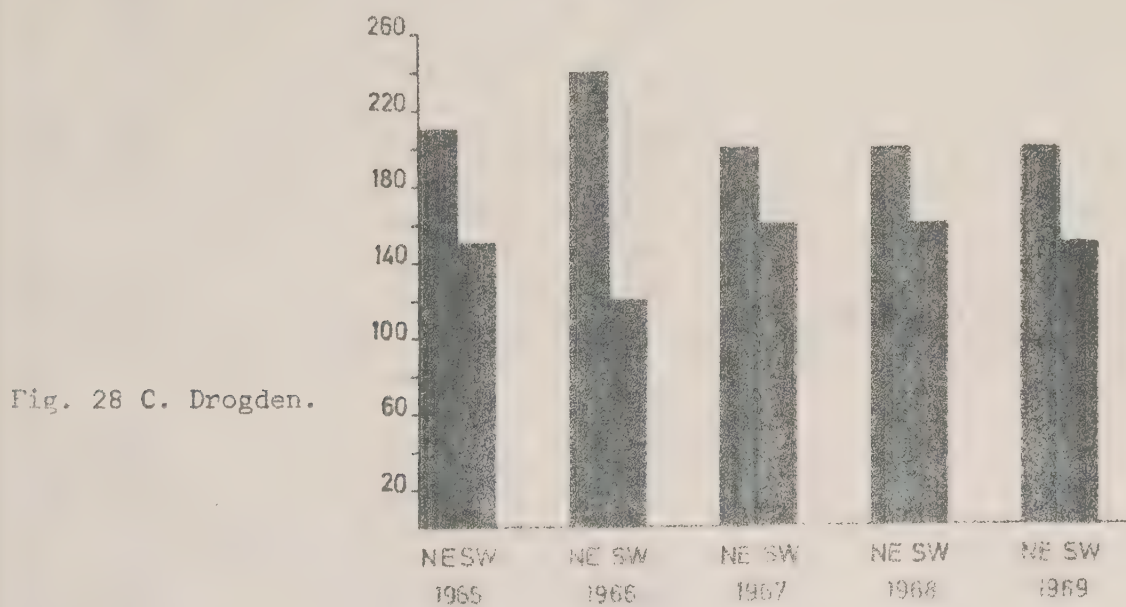


Fig. 28 C. Drogden.

Fig. 28 A - C. Frequencies of current directions during the year at the surface at Kattegatt South, Lappegrund and Drogden.

Calculated from Oceanografiske Observationer fra Danske Fyrskibe og Kyststationer.

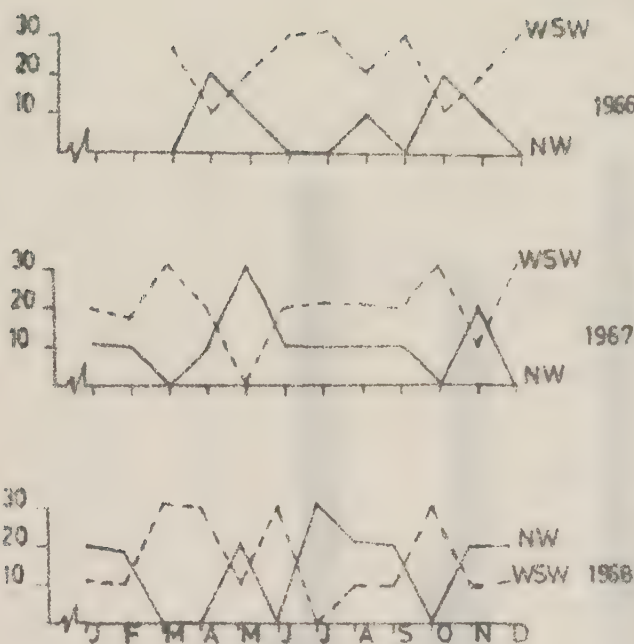


Fig. 29 A. Kattegatt South.

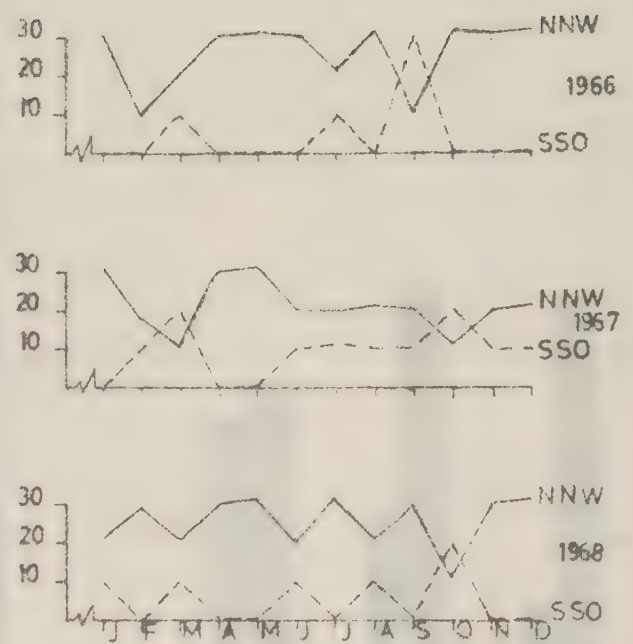


Fig. 29 B. Lappegrund.

Fig. 29 C. Drogden.

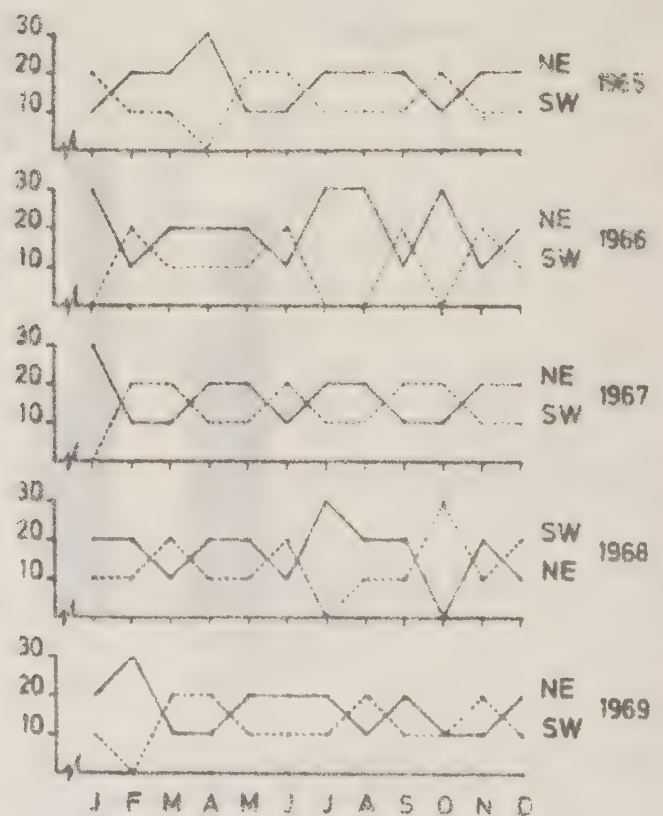


Fig. 29 A - C. The number of days for different current directions at the surface during different months at Kattegatt South, Lappegrund and Drogden. Calculated from Oceanografiske Observationer fra Danske Fyrskibe og Kyststationer.

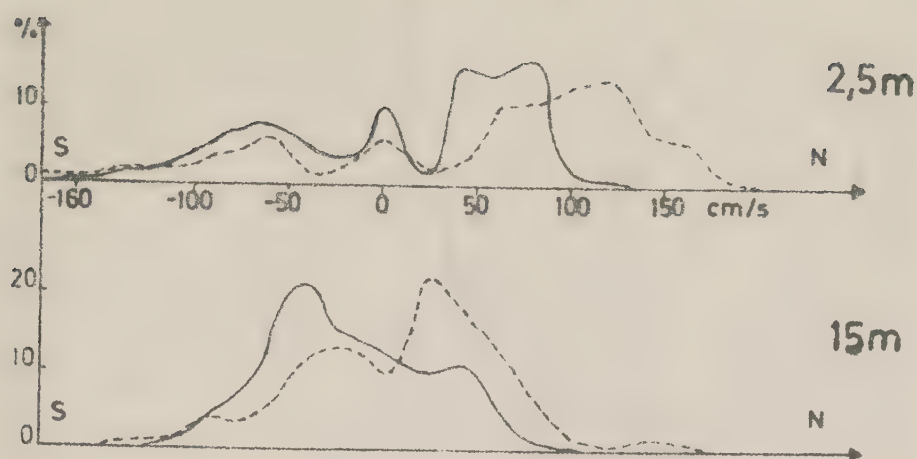


Fig. 30 A. At 2.5 and 15 m in depth 1956-57.

————— summer - - - - - winter

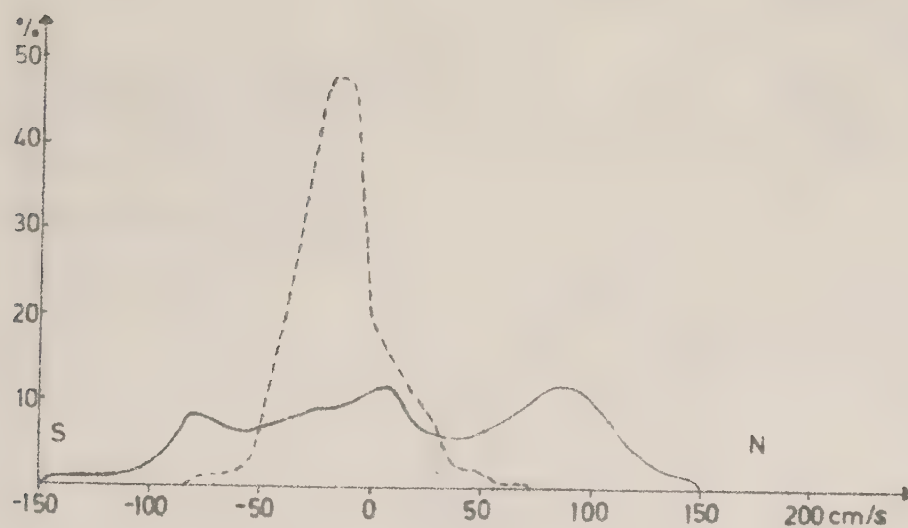


Fig. 30 B. At 2.5 and 23 m in depth 1/9 - 21/11 1909.

————— 2.5 m - - - - - 23 m

Fig. 30 A - B. Frequencies of current velocities at Lappegrund.
From Hermann (1967).

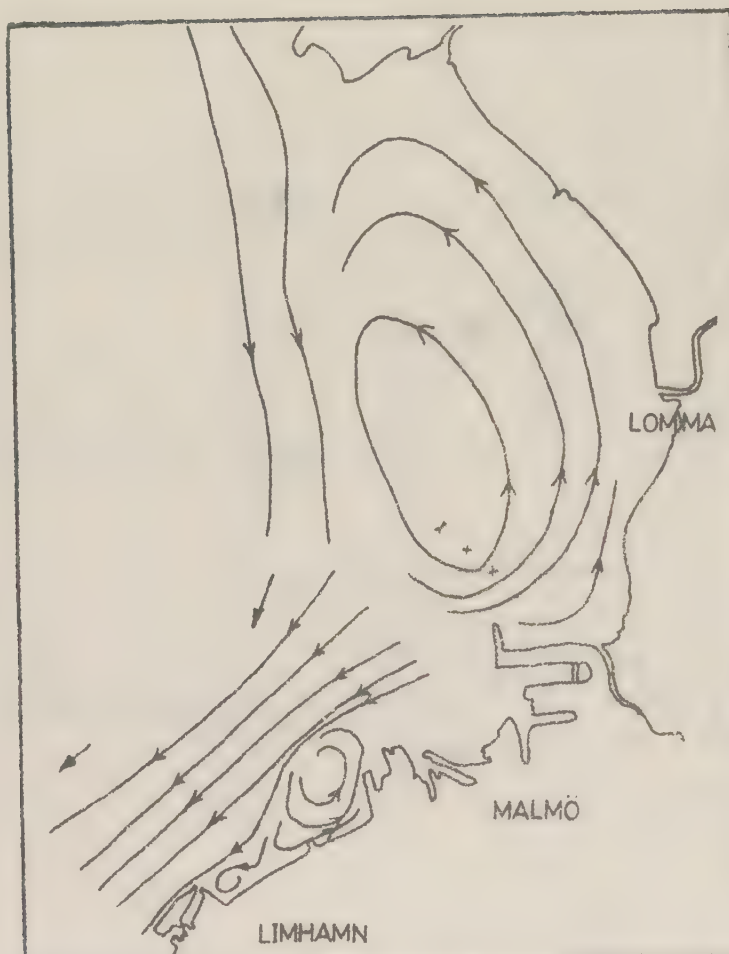


Fig. 31 A.

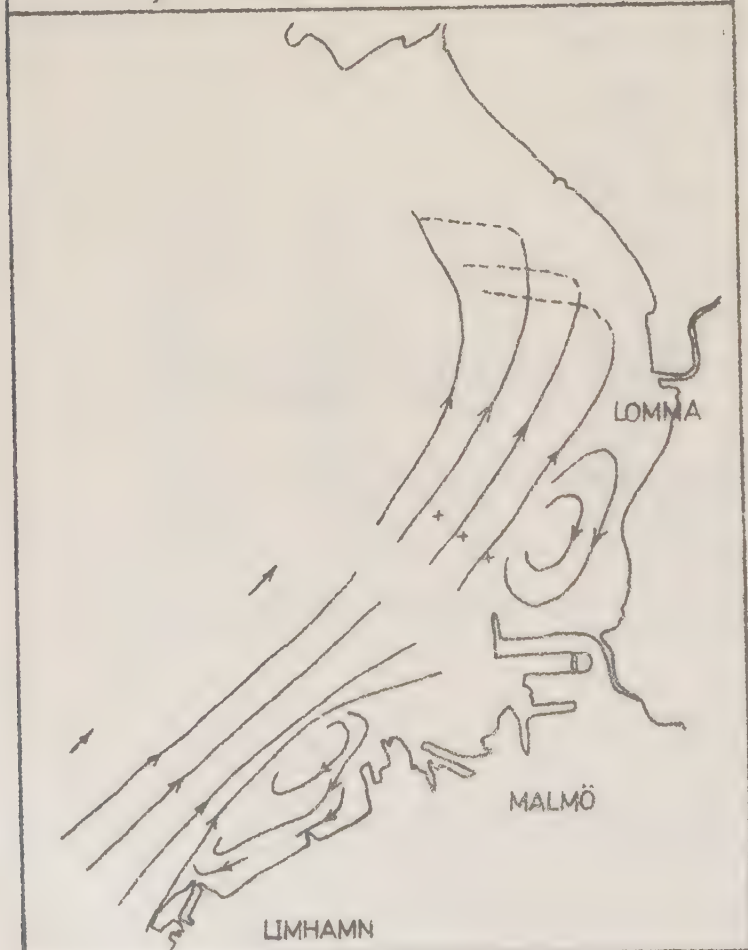


Fig. 31 A - B.

The current directions in Lomma Bay with south-going or north-going main surface current in the Öresund.

From The Danish Isotope Centre (1963).

Fig. 31 B.

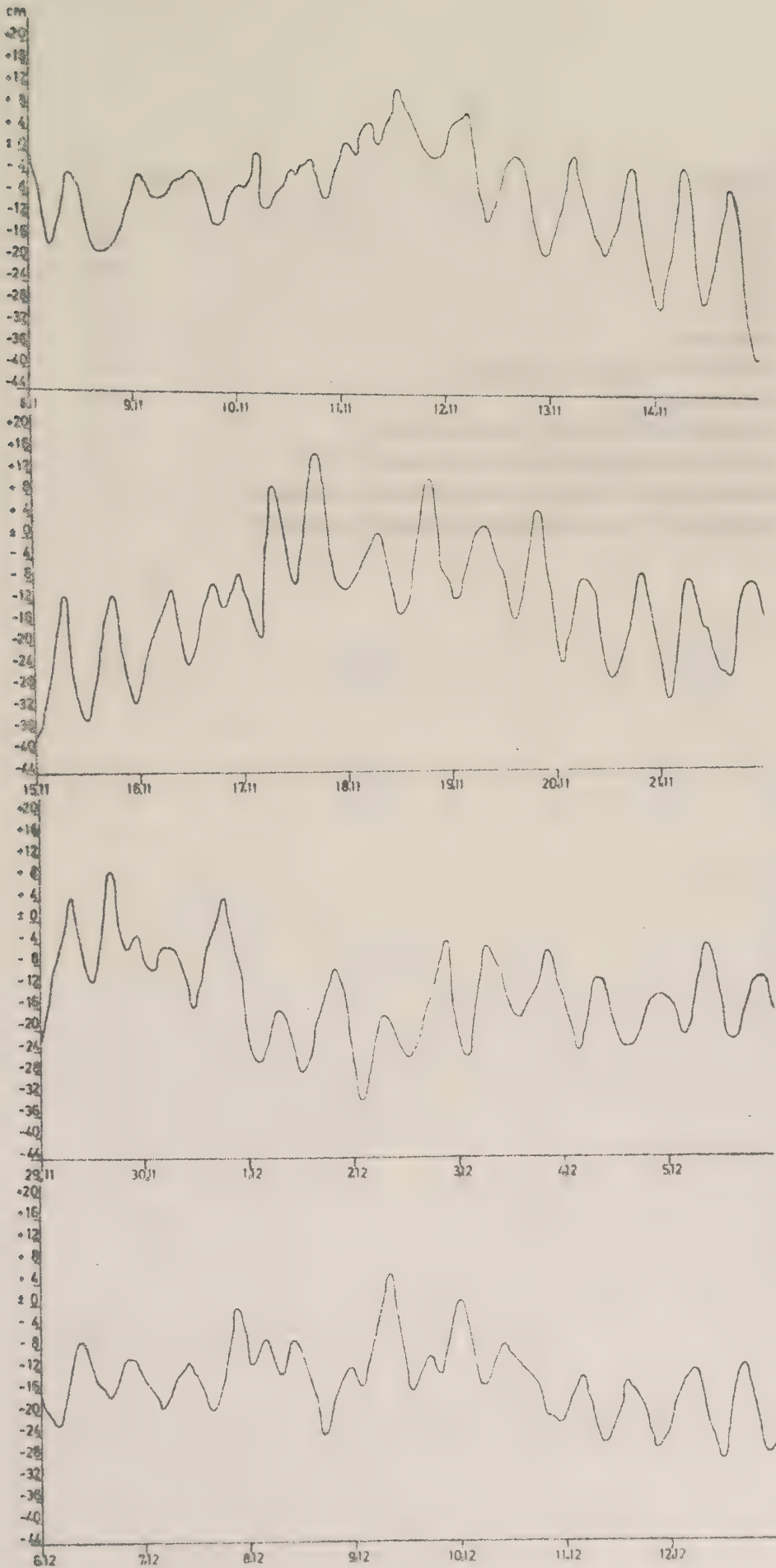


Fig. 32. Changes in water level due to tide in Landskrona harbour 8/11 - 12/12 1967.

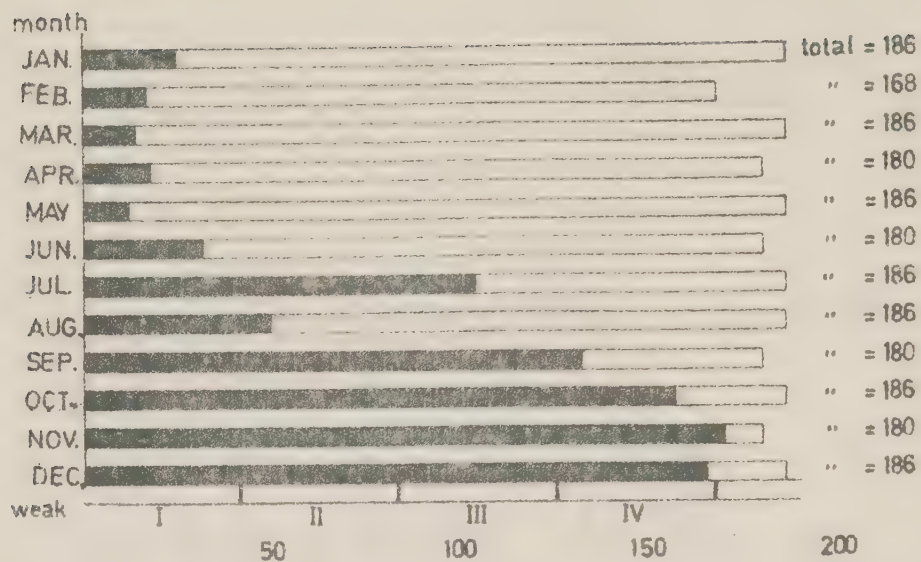


Fig. 33. Number of observations ■ above and □ below the mean water level in Helsingborg harbour, measured every fourth hour during 1968.

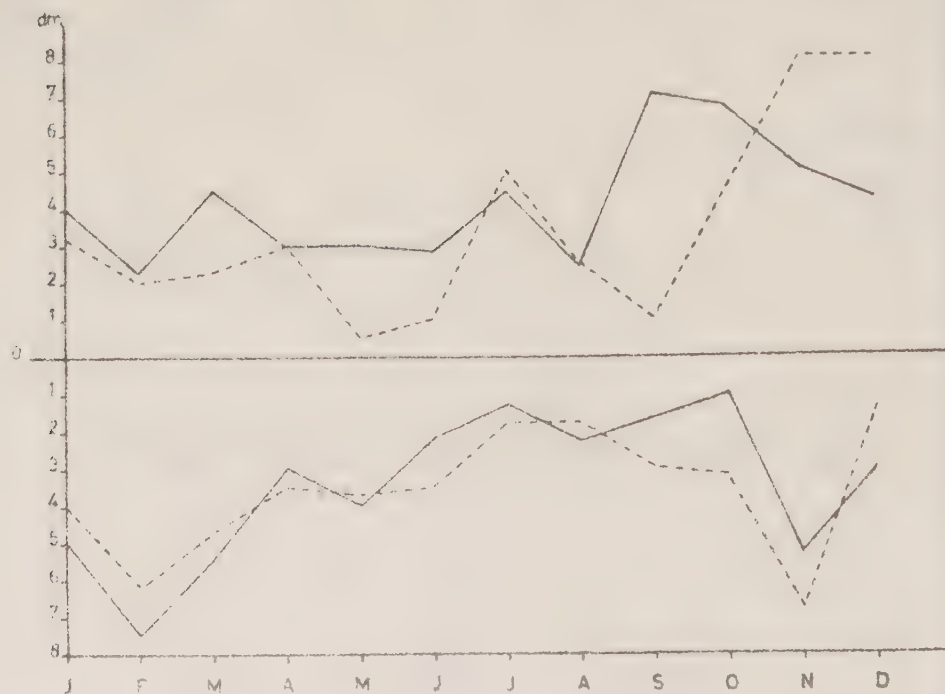


Fig. 34. The monthly extreme values of low and high water level in Helsingborg harbour.

———— 1950 - - - - - 1951

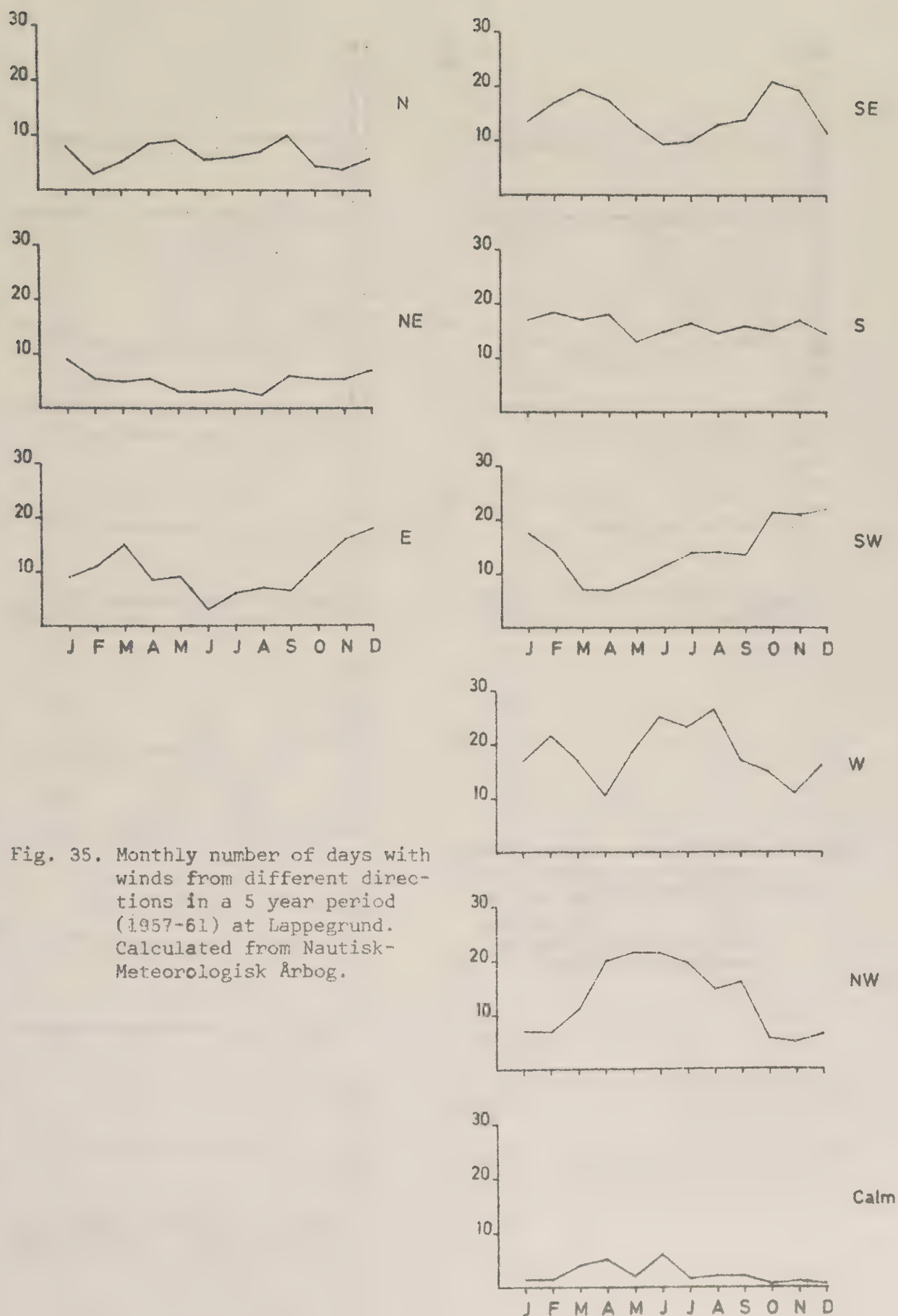


Fig. 35. Monthly number of days with winds from different directions in a 5 year period (1957-61) at Lappegrund. Calculated from Nautisk-Meteorologisk Årbog.

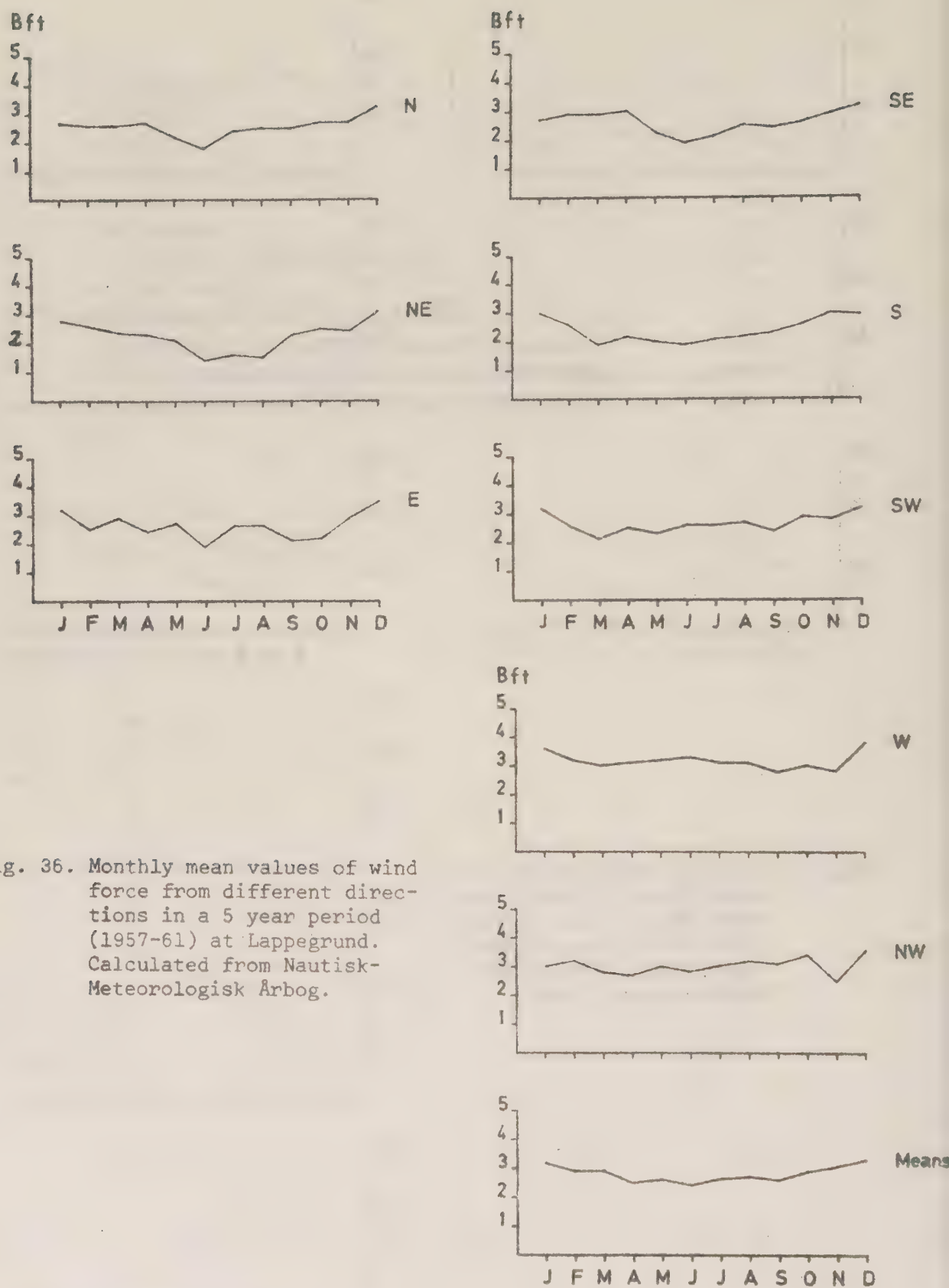


Fig. 36. Monthly mean values of wind force from different directions in a 5 year period (1957-61) at Lappegrund. Calculated from Nautisk-Meteorologisk Årbog.

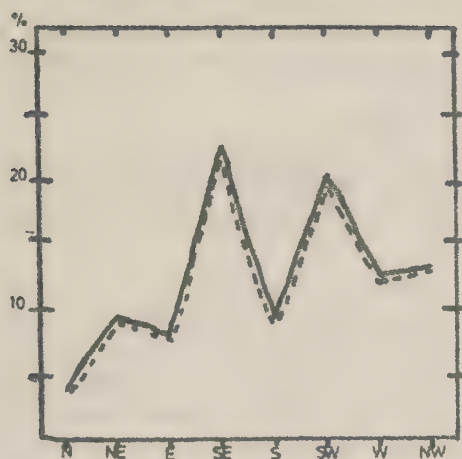
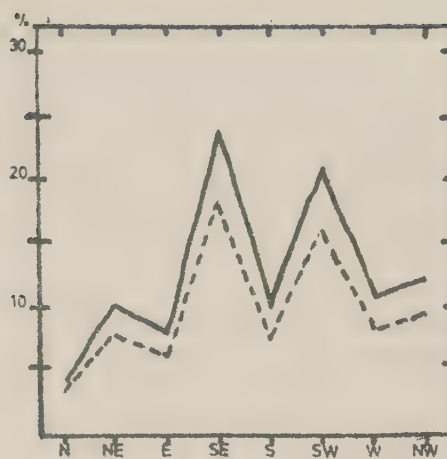
Fig. 37 A. ≥ 1 Bft

Fig. 37 B. 1 - 3 Bft

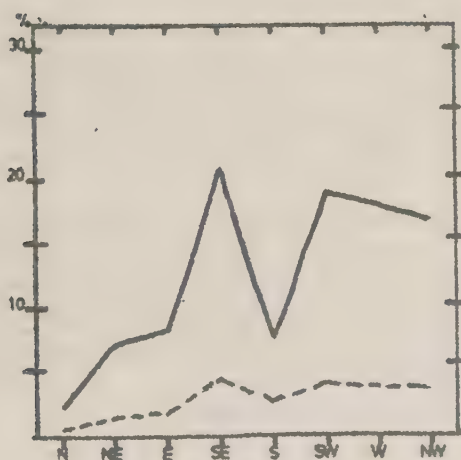


Fig. 37 C. 4 - 6 Bft

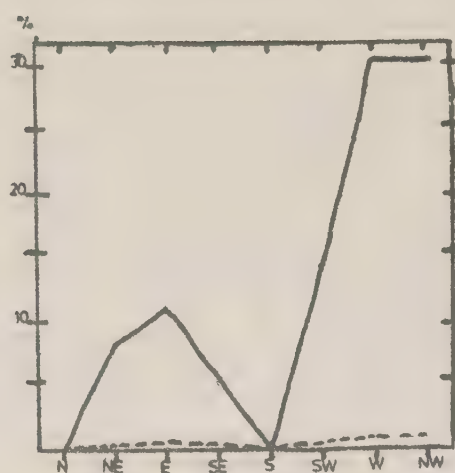
Fig. 37 D. ≥ 7 Bft

Fig. 37 A - D. The force of wind in relation to direction.

----- % days of the time period 1957-61 it was blowing
with the respective force and direction

———— % days of the total number of days during 1957-61
it was blowing with the respective force

OXYGEN

There are comparatively few previous oxygen measurements from the Öresund. Sjöstedt (1936) made in 1931 monthly oxygen determinations in the Landskrona-Ven area and Hermann (1967) presented values from about ten series of oxygen measurements from the entire Öresund. Ljungström (1971) has compared these series of measurements. The oxygen conditions in connection with sand suction for commercial purposes have been discussed by Nordenberg (1971).

For oxygen determinations two methods were used:

1. The Winkler method with Pomeroy's modification according to Martin (1968). This method was used from time to time on water samples from the entire Öresund area and during 1972 and 1973 more intensively along the hydrographical transect from Hornbaek to Viken (p. 7).
2. A YSI oxygen meter with a Servo-Gor recorder was used especially for continuous measurements of the oxygen conditions in drifting algal belts near the bottom.

Compared with the conditions during the 1930s and also the 1960s, the oxygen saturation of the bottom water in the Öresund nowadays seems to be lower during most parts of the year. Table 10 and Fig. 38 A show data for oxygen saturation at 25-30 m in depth in the Landskrona area in 1931, 1967 and 1969 and in the northern Öresund in 1956-64 and 1972. The minimum values occur in September-October and have decreased from 47,8 % in 1931 to 31,9 % in 1972. That the oxygen conditions in the northern Öresund also during the last decade have become more unfavourable is shown in Fig. 38 B. Lower values for oxygen saturation in the bottom water are not restricted to a single sampling station but are found along the entire transect from Hornbaek to Viken (Fig. 39).

For the layers 0 - 15 m in depth both measurements from the Hornbaek-Viken transect (Fig. 39) and from other localities in the Öresund show a normal variation range from about 70 to 110 % oxygen saturation. At some localities around Copenhagen and Malmö, however, there is a total oxygen deficiency with bottoms of black mud, smelling strongly of hydrogen sulfide. This is most probably due to the increasing pollution load in these areas.

During the latter years large amounts of confervoid algae (*Ceramium*, *Cladophora*, *Ectocarpus*, *Pilayella*, *Polysiphonia* sp.) have often been found in May and June, lying loose but vital in belts near the bottom. In such belts the oxygen conditions during the night have been studied by means of continuous measurements for 4 - 6 days. The oxygen values were normal (95 - 100 % saturation) during the day, whereas at night the oxygen saturation decreased continuously, the lower values of 60 - 75 % saturation being obtained just before sunrise.

pH-VALUE

Results of some measurements of pH-value from the Sound are found in the report of Hermann (1967). The normal variation in pH-value in surface sea water is, according to Harvey (1966), from 8.0 to 8.4. In brackish water slightly lower values, from 7.9 to 8.2, could be expected.

Method: Measurements of the pH-value were made with a Beckman 62 pH-meter from 1968 to 1970 and from June 1970 with a Radiometer 26 pH-meter with an accuracy of about 0.005 units. Some of the measurements were made at sea and some at the laboratory, always within two hours after the water sample had been taken. All measurements were performed at 20°C.

Measurements of pH-value from the entire Öresund area during six years are summed up in Table 11 and Fig. 40. Both the median and mean values are 7.92 and the variation shows a small skewness. In several cases abnormal values of 6.0 - 7.8 and 8.4 - 9.0 were obtained. The low values are as a rule found in Lomma Bay and outside Landskrona and Helsingborg. The higher are found in shallow bays with a high amount of detached but living algae. The daily pH-variation at such a locality is shown in Fig. 41, where the extreme values are 7.8 and 8.6. The variation in in the author's material as a whole is larger than that mentioned by Hermann (loc. cit.). 85 % of his values were between 8.0 and 8.4.

Table 10. Monthly oxygen saturation values in % at 25-30 m in depth in the Öresund in 1931, 1967, 1969 and 1972.

1931 by Sjöstedt (1936) 1967, 1969 by Hermann in Ljungström (1971)

Month	The Landskrona Deep				Hornbaek-Viken	
	1931		30 m		25 m	
			1967	1969	1972	
Mar.					6/3	81.6
Apr.	10/4	76.8	5/4 65	1/4 72.5	4/4	60.4
				10/4 61.0	18/4	61.9
				25/4 60.3		
May	10/5	77.0		28/5 64.8	3/5	66.2
					16/5	54.1
Jun.	17/6	77.1	14/6 56.1	18/6 53.4		
			2/7 63.8			
Jul.	15/7	64.6		15/7 50.7	27/7	72.8
Aug.	15/8	66.4	2/8 57.6	15/8 43.4		
Sep.	19/9	55.3	12/9 39.8	3/9 40.0	4/9	31.9
			30/9 33.4	24/9 69.3	25/9	59.7
Oct.	24/10	47.8	17/10 44.9		11/10	61.3
					30/10	41.4
Nov.	16/11	51.9				

Table 11. pH-values from the entire Öresund area in 1968 - 1974.

q_1	q_2	q_3	$q_3 - q_1$	R	g_1	$\bar{x}$	n
7.69	7.92	8.13	0.44	3.0	-0.15	7.92	380

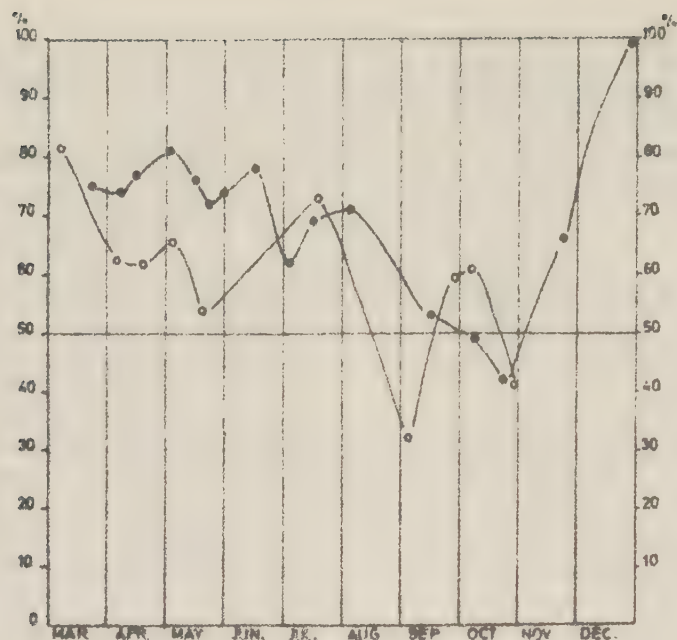


Fig. 38 A. ● The Ven Deep in 1931, Sjöstedt (1936)
○ Station 3 on the transect Hornbaek - Viken

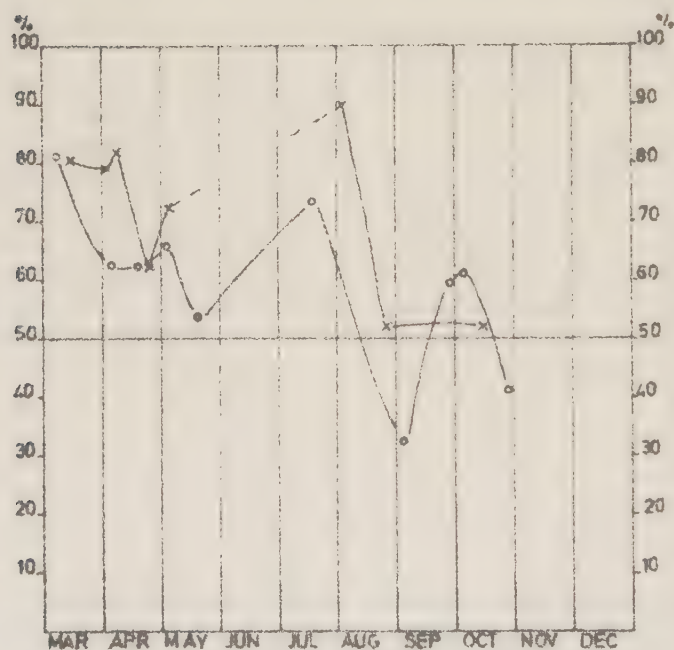


Fig. 38 B. x East of Hornbaek in 1956-64, Hermann (1967)
○ Station 3 on the transect Hornbaek - Viken

Fig. 38 A - B. The monthly variation in oxygen saturation at 25 m in depth in the Öresund in 1931, 1956-64 and 1972.

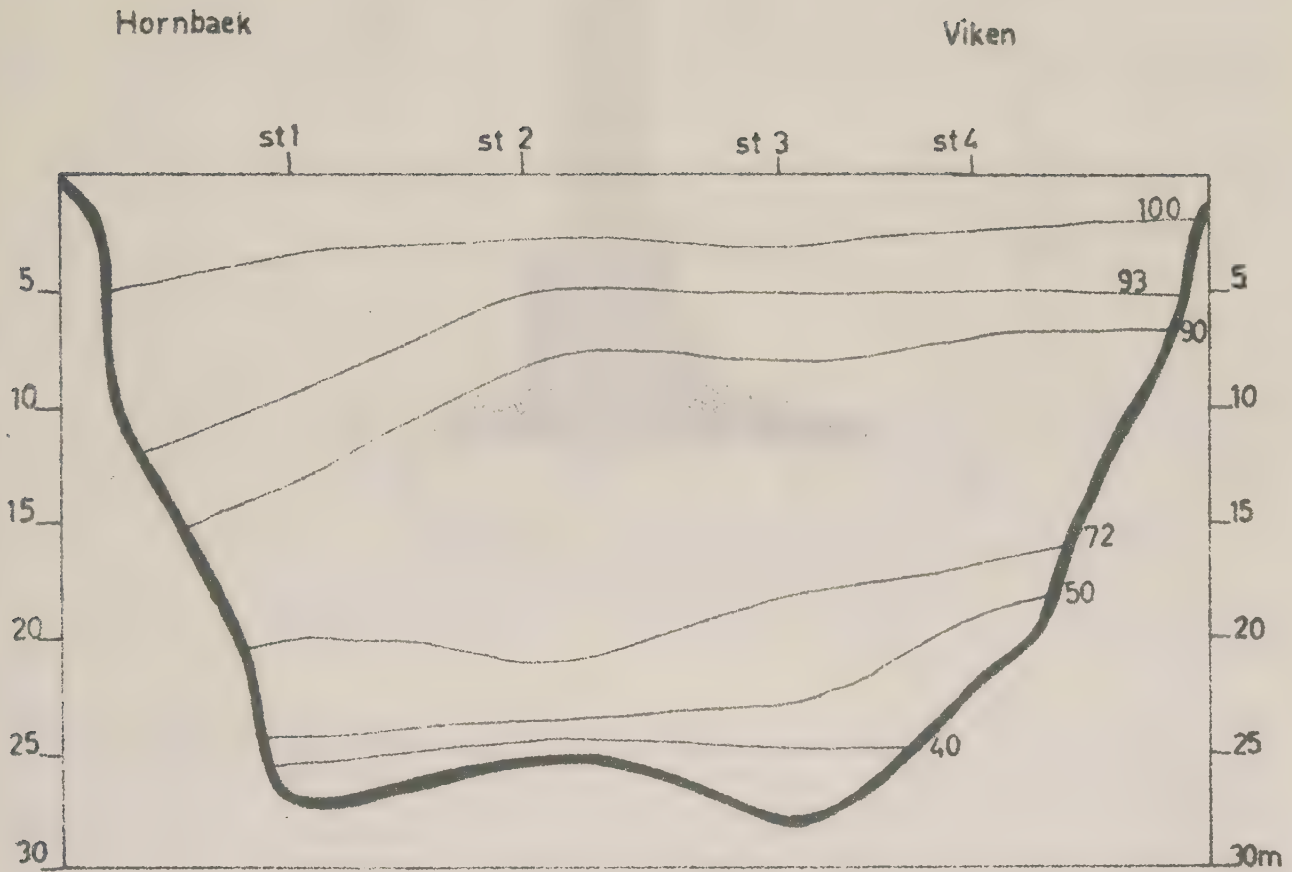


Fig. 39. Oxygen saturation in % at different depths along the transect Hornbaek - Viken 30/10 1972.

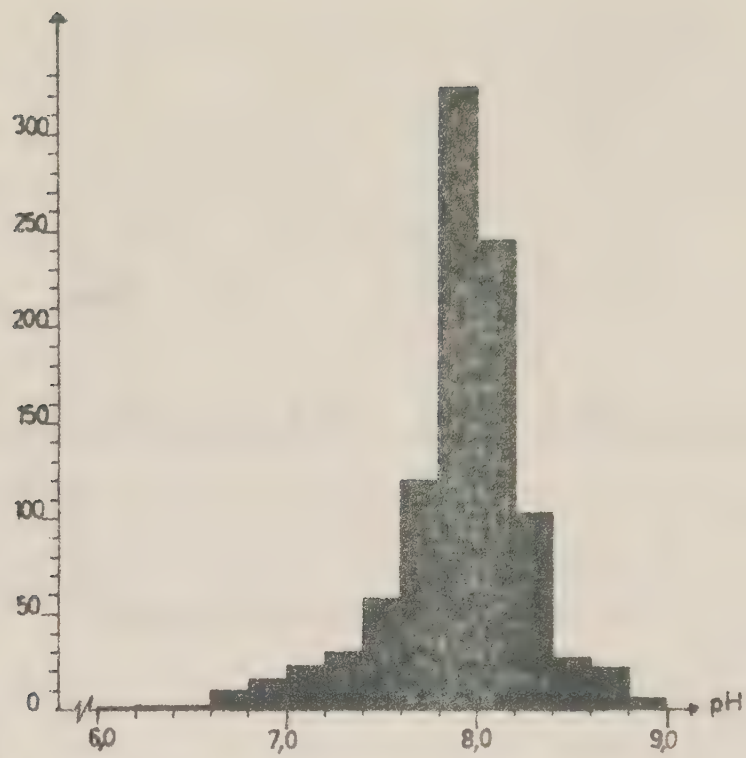


Fig. 40. Frequencies of pH-values from the Öresund in 1968-1974.

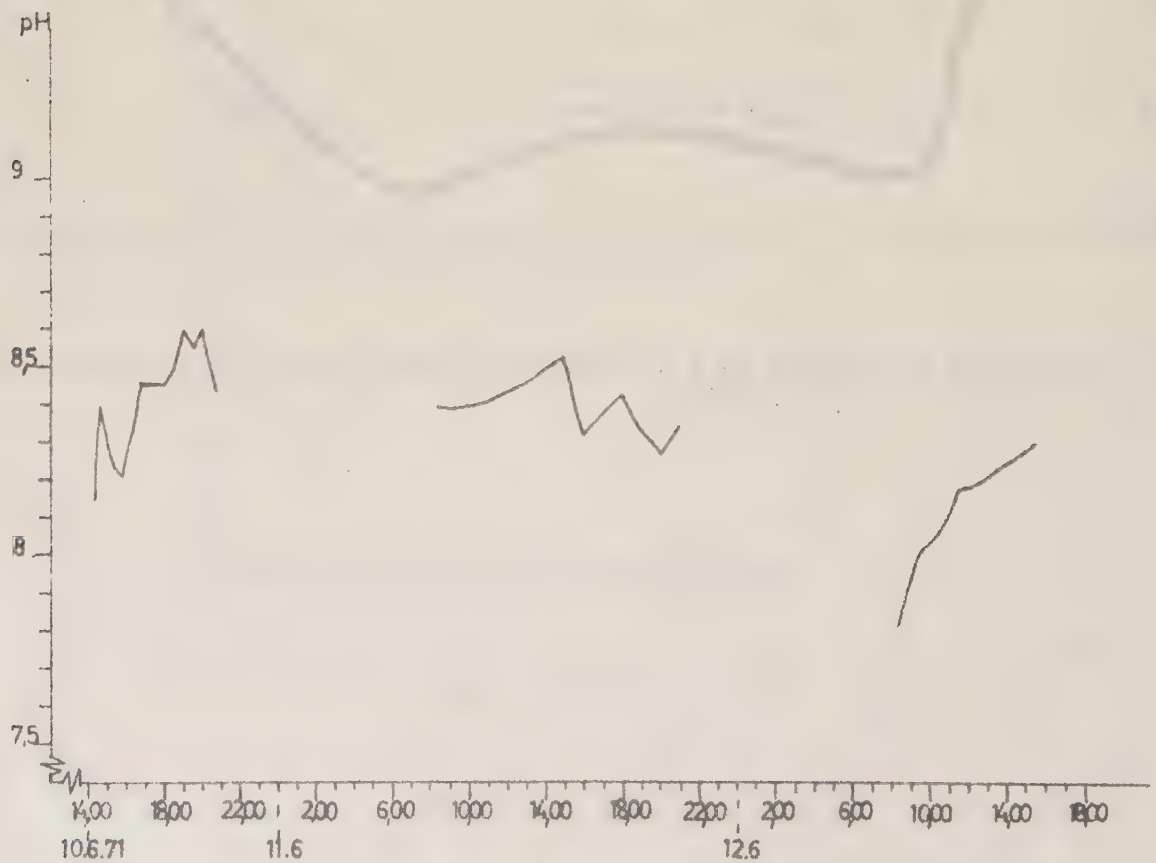


Fig. 41. Variation in pH-value in surface water during the day at Lerhamn 10/6 - 12/6 1971.

PHOSPHORUS

The phosphorus content in natural waters has become a matter of great interest during the last decade. Ljungström (1971) has calculated the annual discharge of phosphorus into the Öresund from the Swedish side and states that the annual amount of phosphorus has increased five-fold during the period 1930-1970 to approximately 4000 tons a year. The discharge at different localities along the Swedish side of the Öresund can be seen in Fig. 42. The discharge from the Danish side of the coast is probably of the same magnitude. The total discharge of phosphorus per year into the Öresund is probably 7-8000 tons.

In this treatise the phosphorus conditions will be discussed under the following headings: phosphate phosphorus ($P-PO_4$), particulate phosphate phosphorus, total phosphorus (Tot-P) and organic phosphorus.

Methods:

1. Phosphate phosphorus determinations were performed according to Murphy & Riley (1962). The analyses were made with a Unicam spectrophotometer with 5 cm cells from October 1967 to April 1970 and with a Hitachi 139 spectrophotometer with 10 cm cells after April 1970. The accuracy of the measurements is approximately $\pm 1 \mu\text{g/l}$ or better.
2. Particulate phosphate phosphorus is defined as the difference between an unfiltered and a filtered sample of $P-PO_4$, drawn from the same sample flask. The sample was filtered through a 0.22μ Millipore membrane filter. In some cases the filtered samples gave higher values than the unfiltered, as some filters contaminated the samples with 4-6-(8) $\mu\text{g P/l}$. The process was carefully tested and it was found that such contaminations were abundant in only a few batches of filters. The results from the contaminated samples were rejected.
3. Total phosphorus was determined according to Koroleff (1970). A Hitachi 139 spectrophotometer with 10 cm cells was used.
4. Organic phosphorus is defined as the difference between total phosphorus and phosphate phosphorus.

Phosphate phosphorus

The phosphate condition of the Öresund has earlier been dealt with by Sjöstedt (1936), Steemann Nielsen (1937, 1940), Hermann (1967), Vallin (1968) and von Wachenfeldt (1971). There are also some measurements from the Fishery Board of Sweden. The measurements from the 1930s were made with various methods with probably lower accuracy, partly due to the rather low content in the Öresund water at that time. But on the whole, the magnitude of the values ought to be correct and comparisons with the present material are possible. Sjöstedt (loc.cit.) made a series of measurements off Landskrona every month during 1931. Steemann Nielsen's (1937) measurements were carried out SE of Helsingör. By Steemann Nielsen (1940) there are two measurements from each Helsingör and Kullen. Hermann's (loc.cit.) material is taken at 11 stations on a line from Drogden to Hornbaek and the measurements of Vallin (loc.cit.) are from the vicinity of Landskrona. Since autumn 1967 to the end of 1973 the author has made about 4000 phosphate phosphorus analyses.

A comparison of phosphate phosphorus values from the 1930s till 1971 is made in Table 12. There is a good correlation between the 1931 surface values from the Landskrona Deep and those from 1932-33 at Helsingör. The values are 0.6 and 1.5 $\mu\text{g/l}$, respectively. The difference may be within the range of error. Vallin's (1968) surface values from the Landskrona Deep in the period 1950-65 show a good coincidence with the mean values from the whole area, which the author has calculated from Hermann's (1967) tables. The values are 8.7 and 8.2 $\mu\text{g/l}$, respectively. The tendency in the deeper water layers is almost the same. However, there is one discrepancy, the high value at 15 m in depth at Helsingör in 1932-33. A closer examination shows that the variation is very large, 0 - 17.7 $\mu\text{g/l}$, with high values during autumn, winter and spring and no phosphate in summer. Furthermore, the samples were taken near the bottom and according to Steemann Nielsen (1937) they were rich in detritus. When the mean values for the period 1968-71 are compared with earlier values, it is evident that the phosphate phos-

phorus content of the water has increased strikingly. The same trend is shown in Fig 43.

To get an idea of the distribution of the nutrient salts within the Öresund, the Sound has been divided into four areas:

1. from Gilleleje-Kullen to Helsingör-Helsingborg (the border between the north and the central part, cf. Fig. 2);
2. from Helsingör-Helsingborg to Vedbaek-Landskrona;
3. from just south of the line Vedbaek-Landskrona to Dragör-Limhamn;
4. south of the line Dragör-Limhamn.

The results from the measurements of phosphate phosphorus in the above four areas during 1971, 1972 and 1973 are shown in Table 14. The median values vary between 5.3 and 29.0 (38.3) $\mu\text{g/l}$. Within all areas there is a trend to higher values in the surface, lower at 5 - 10 m and then increasing toward the bottom. The quartile range and the variation breadth decrease with increasing depth. When the different areas are compared, it is obvious that the southernmost area has the lowest levels of phosphate. For the other three areas there is no clear difference between the surface values. For depths from 5 to 25 m, however, the highest load of phosphate is found in the area Helsingborg-Landskrona. A possible explanation of the larger quartile range and variation breadth for the surface values may be that in shallow water near shore the concentration of phosphate is often considerably higher than at sea (Fig. 44).

Continuous measurements of phosphate phosphorus at the same locality show that there exists a short-term variation in the phosphate concentration of the water. This is exemplified in Fig. 45. Samples taken along the coast at many localities within a few hours show that there can be a large difference in the content of phosphate between near by localities (Fig. 46). This is also the case in the surface water in the middle of the Öresund (Fig. 47). When samples were taken simultaneously at eight localities every hour of the day, it was possible to show how a phosphate front was moving northwards along the coast (Fig. 48 A - C). A large number of measurements shows that this is a common phenomenon in the Öresund area. This may partly be due to the complex current and wind situation. The water in the bays, such as Lomma and Lundåkra Bay, circulates within the bays for some time (cf. Fig. 31 A - B) during which the load of different compounds increases. With changing wind and current directions these water masses move northwards without mixing with the surrounding waters (cf. p. 50).

In all natural bodies of water there is a seasonal variation in the phosphate content with higher values during the cold months and lower during the vegetation period. In Figs. 49 and 50 A - B the monthly mean values of phosphate phosphorus at Kullen and Lappegrund are shown, compared with earlier measurements at Helsingör. Here also, the great change since 1932-33 is clearly seen. In the 1930s the values in the surface water and even at 15 m were zero during the vegetation period. At Lappegrund nowadays lower values are found during parts of the vegetation period and at Kullen only a slight tendency to lower values in spring can be seen.

Particulate phosphate phosphorus

There are no previous determinations of particulate phosphate phosphorus available from the Öresund area. In the present project, measurements of particulate phosphate phosphorus were performed on about 1300 water samples, taken from the entire Öresund area. The majority of the values varies from 0 to 2 $\mu\text{g/l}$ (Table 13). Only 12 % of the values exceed 10 $\mu\text{g/l}$. The very few high values were taken in the vicinity of Landskrona harbour and Helsingborg and are probably due to high concentrations of sewage in the water.

Total phosphorus

Information on the total phosphorus content in the Öresund is sparse. Waern (in Ljungström, 1971) made a few measurements from the surface water only, on two cruises along the Swedish coast in the summers of 1964 and 1968. In his 13 samples the values varied between 10 and 25 $\mu\text{g/l}$ with the highest value from the vicinity of Helsingborg. There are also some measurements in the hydrographical reports

from the Fishery Board of Sweden. The author began with total phosphorus determinations in September 1970 and since then approximately 3500 analyses have been made.

In Table 15 are shown total phosphorus values at different depths in the four areas mentioned above (p. 72). The median values vary between 20.0 and 51.4 $\mu\text{g/l}$. The higher values are found in the surface layer in the northernmost area, at all depths in the Helsingborg-Landskrona area and in the surface and bottom layers in the area south of Landskrona to Limhamn. The highest load is found in the Helsingborg-Landskrona area and, furthermore, the total phosphorus values in this area increase toward the bottom. The inflowing Baltic and Kattegatt waters generally contain less total phosphorus. The load of total phosphorus in near shore areas is usually higher than at sea with the highest values from south of Kullen to Landskrona (Fig. 44).

As has already been shown with phosphate phosphorus, there is also a large variation in the amount of total phosphorus at the same station for different hours of the day (Figs. 45 and 48 A - C) and even between stations not far from each other (Fig. 46). An attempt to explain this short-term fluctuation is given above (p. 72). There is no demonstrable seasonal variation in the amount of total phosphorus (Fig. 49).

When the total phosphorus in relatively shallow waters, 0 to 15 m in depth, is considered, it is evident that in an area like the Öresund the values can be a little misleading. The amount of organic phosphorus bound in the benthic algae is so high that it must be taken into consideration in the total phosphorus measurements.

Organic phosphorus

The determined organic phosphorus derives partly from living or dead phytoplankton and fragmented benthic algae and partly from organic compounds from sewage outlets. Also for the organic phosphorus there is a considerable variation for the same station during the day (Figs. 45 and 48 A - C) and between adjacent localities (Figs. 46 and 48 A - C).

When the phosphorus conditions of the Sound are evaluated, the following points have also to be considered.

1. There is an influx of phosphorus from both the Baltic and the Kattegatt, as the phosphorus content of the water has also increased in these areas, Fonselius (1969). The inflow from the Baltic to the Öresund has been calculated by Ljungström (1971) as 1000 tons P/year. This figure seems, however, to be too low. A more realistic value, based on the present data, may be about 7000 tons per year.
2. There is recirculation of phosphorus within the Öresund caused by uncontrolled growth of benthic algae from which phosphorus is washed out when the algal masses decay. The phosphorus accumulation of the algae in the Öresund has apparently increased during the latter decades (cf. section III).
3. There also occurs phosphorus accumulation in and leakage from the sediments.

Table 12. Mean values of $P-PO_4$ in $\mu g/l$ at some localities in the Öresund 1931-1971.

Depth	Landskrona Deep 1931	SE Helsingör 1932-33	Landskrona Deep 1950-65	Hornbaek- Drogden 1956-64	Landskrona Deep 1970-71	Lappegrund 1968-70
0 m	0.6	1.5	8.7	8.2	21.3	42.2
5 m	0.7	2.1	8.1	7.9	22.8	22.7
10 m	1.6		12.4	13.5	27.1	27.3
15 m	1.2	6.1	13.3	21.0	32.9	46.1
20 m	4.5		25.4	22.8	49.1	32.4
25 m	4.3		31.3	27.2	41.7	49.1
30 m	4.3		32.6	27.2	40.5	35.6
35 m	4.3				41.0	45.3
40 m	7.9		34.4	22.9	47.3	35.8
50 m			35.0	27.3	28.0	

1931 recalculated from Sjöstedt (1936)
 1932-33 recalculated from Steemann Nielsen (1937)
 1950-65 recalculated from Vallin (1968)
 1956-64 calculated from Hermann (1967)

Table 13. Frequencies of the content of particulate $P-PO_4$ ($\mu g/l$) in the Öresund in 1971.

Class	f	f/w
0-2	690	345
2-4	250	125
4-6	113	56.5
6-10	115	28.7
10-20	95	9.5
20-50	51	1.7
50-100	11	0.22
100-200	6	0.06
200-300	3	0.03

f = frequency
 f/w = class breadth

Table 14. The concentration of P-PO₄ in µg/l at different depths in four areas in the Öresund in 1971, 1972 and 1973.

q_1 q_2 q_3 = quartiles g_1 = skewness n = number of observations
 $q_3 - q_1$ = quartile range R = variation breadth

Area	Depth	q_1	q_2	q_3	$q_3 - q_1$	g_1	R	n
Gilleleje-Kullen to Helsingör-Helsingborg	0 m	10.4	19.2	31.0	20.5	3.69	215	420
	5 m	5.4	11.6	22.9	17.5	2.45	110	132
	10 m	3.4	9.6	17.0	13.6	0.77	80	81
	15 m	6.5	13.3	21.4	14.9	0.91	55	80
	20 m	13.5	20.7	27.0	13.5	0.08	45	66
	25 m	16.1	22.3	27.5	11.4	0.06	45	45
Helsingör-Helsingborg to Vedbaek-Landskrona	0 m	13.0	19.8	28.5	15.5	3.81	275	616
	5 m	11.7	18.4	26.9	15.2	3.51	185	299
	10 m	14.6	21.2	29.2	14.6	1.86	210	267
	15 m	17.4	25.2	32.3	14.8	3.45	175	210
	20 m	22.1	28.8	35.8	13.7	2.25	125	140
	25 m	25.7	29.0	36.8	11.1	2.03	95	95
South of Vedbaek- Landskrona to Dragör-Limhamn	0 m	11.7	20.0	30.9	19.2	2.67	165	165
	5 m	6.0	10.5	17.2	11.2	1.73	60	153
	10 m	9.8	15.0	20.0	10.2	1.85	65	101
	15 m	18.3	22.5	26.9	8.6	-0.08	45	38
	20 m	30.0	38.3	43.3	13.3	0.49	30	10
South of Dragör- Limhamn to Falsterbo	0 m	2.6	5.5	9.1	6.5	1.60	30	81
	5 m	2.6	5.3	8.6	6.0	2.68	55	119
	10 m	3.0	6.2	9.4	6.4	0.77	20	23

Table 15. The concentration of Tot-P in $\mu\text{g/l}$ at different depths in four areas in the Öresund in 1971, 1972 and 1973.

q_1 q_2 q_3 = quartiles g_1 = skewness n = number of observations
 $q_3 - q_1$ = quartile range R_1 = variation breadth

Area	Depth	q_1	q_2	q_3	$q_3 - q_1$	g_1	R	n
Gilleleje-Kullen to Helsingör-Helsingborg	0 m	27.1	42.1	55.7	28.6	0.97	175	391
	5 m	12.8	23.5	36.2	23.5	0.68	75	96
	10 m	11.8	20.0	34.3	22.5	0.94	85	81
	15 m	15.5	26.1	40.0	24.5	1.26	120	79
	20 m	13.3	28.6	48.8	35.4	0.73	90	61
	25 m	15.8	28.5	39.2	23.3	0.65	85	54
Helsingör-Helsingborg to Vedbaek-Landskrona	0 m	24.4	36.5	56.7	32.3	1.43	180	535
	5 m	26.6	39.5	58.5	31.9	1.45	190	302
	10 m	28.6	40.9	62.5	33.9	0.80	135	253
	15 m	33.7	44.5	60.9	27.2	0.96	175	205
	20 m	33.6	47.1	59.5	25.9	0.69	130	130
	25 m	39.7	51.4	67.0	27.3	0.52	160	191
South of Vedbaek- Landskrona to Dragör-Limhamn	0 m	31.7	51.3	70.0	38.3	1.13	200	531
	5 m	29.2	22.8	35.0	25.8	1.47	115	106
	10 m	12.9	25.0	38.8	25.9	1.21	110	86
	15 m	15.0	28.8	42.5	27.5	0.70	85	38
	20 m	13.8	42.5	75.0	61.2	0.72	100	12
South of Dragör- Limhamn to Falsterbo	0 m	16.9	26.2	32.9	16.0	2.10	120	123
	5 m	17.4	25.7	34.4	17.0	0.88	85	158
	10 m	8.6	25.4	30.6	22.1	-0.01	50	55

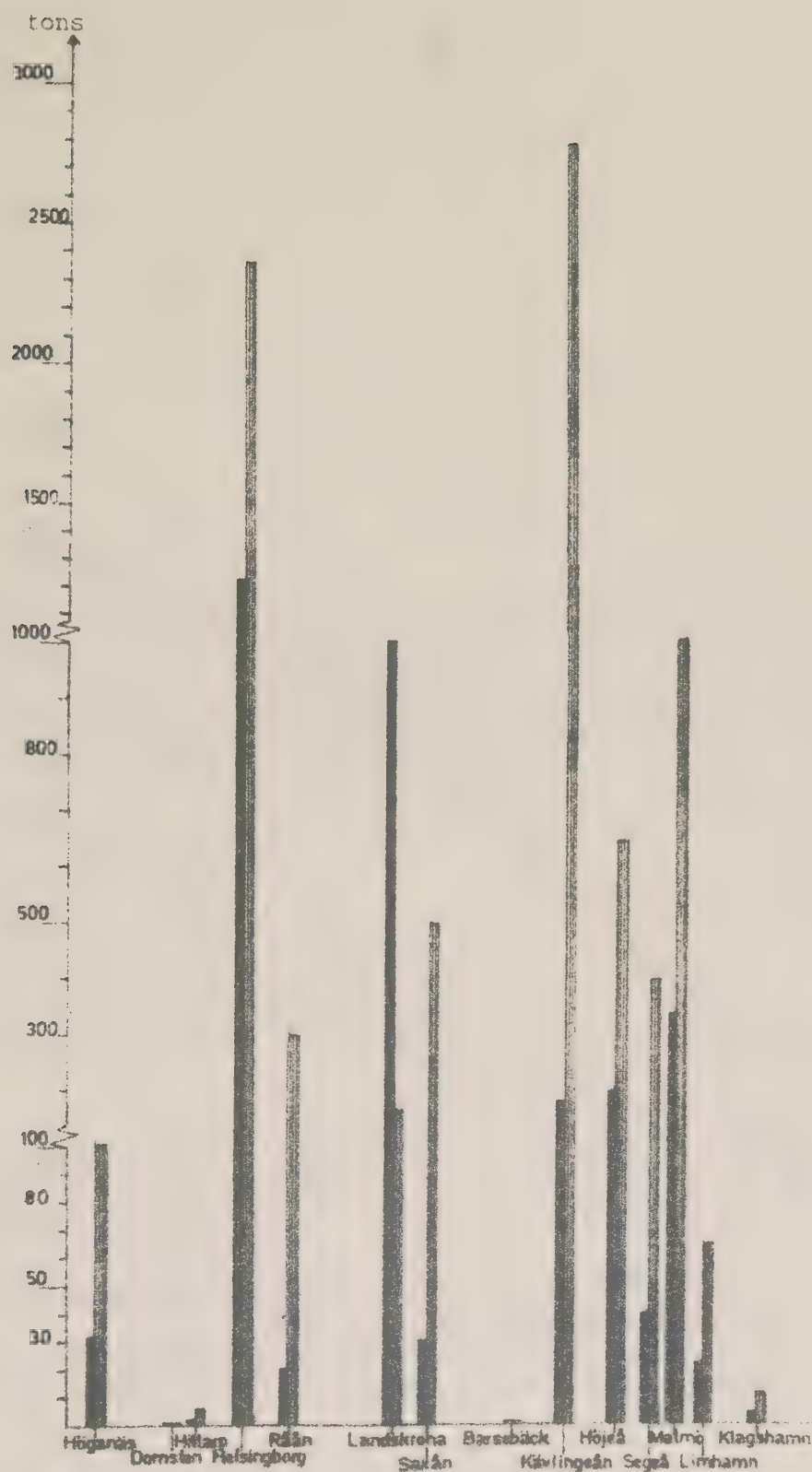


Fig. 42. The calculated annual discharge of phosphorus and nitrogen in tons from the Swedish coast into the Öresund in 1972. ■ phosphorus ▨ nitrogen
Calculated from figures given by the Region. Board for Environ. Protection.

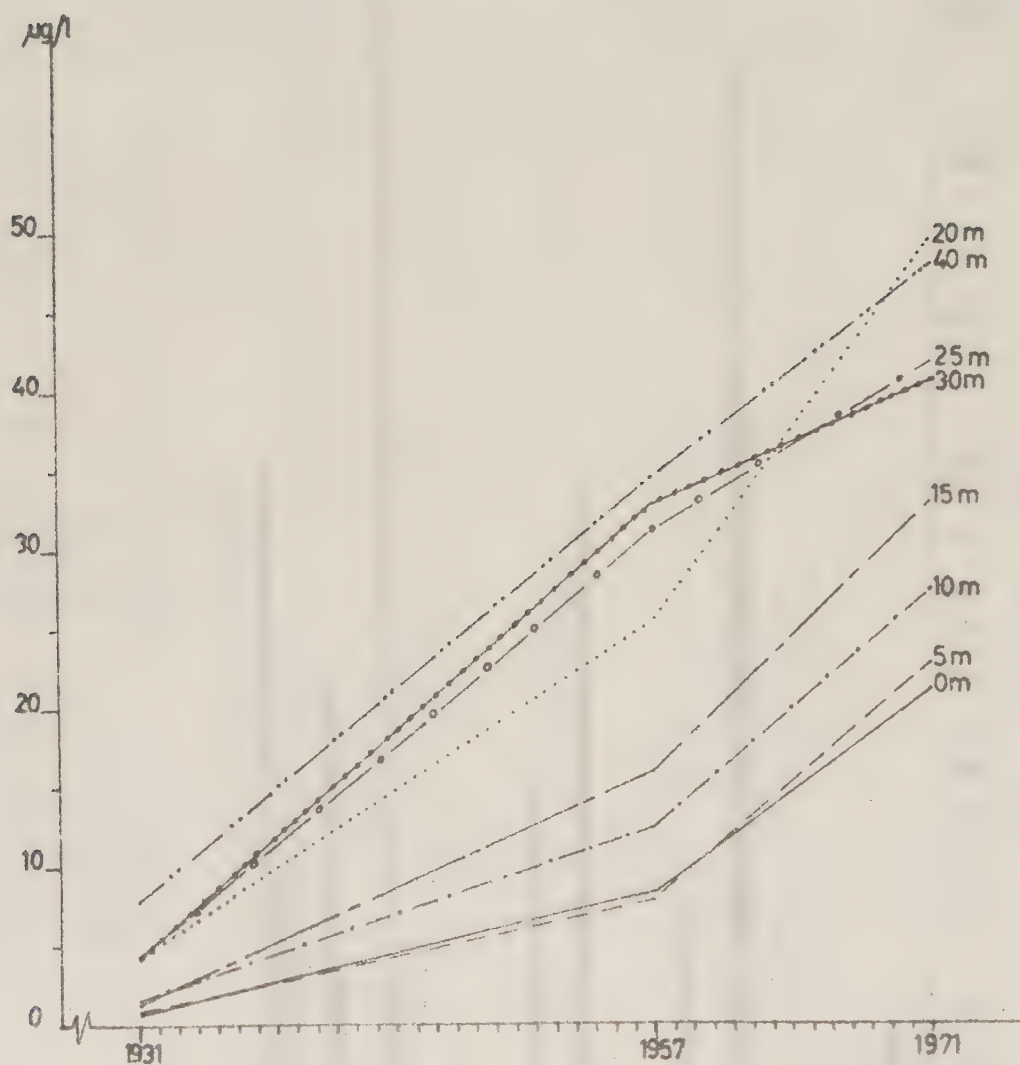


Fig. 43. The P-PO₄ content in µg/l at different depths at the Landskrona Deep 1931, 1957 and 1971.
 Values from 1931 recalculated from Sjöstedt (1936).
 Values from 1957 recalculated from Vallin (1968).

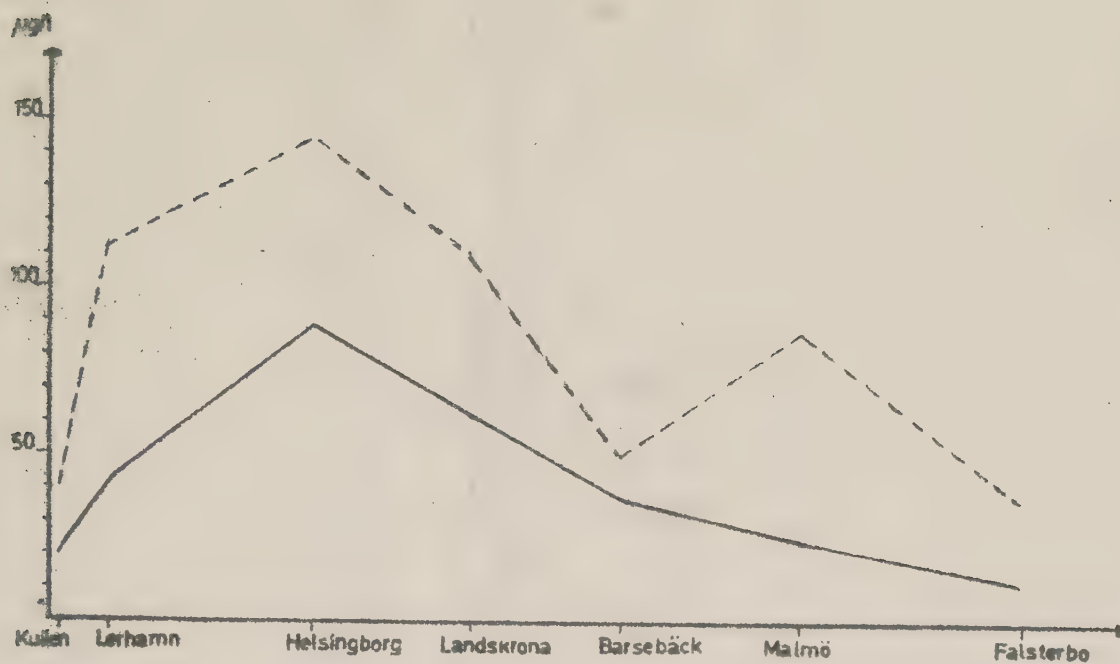
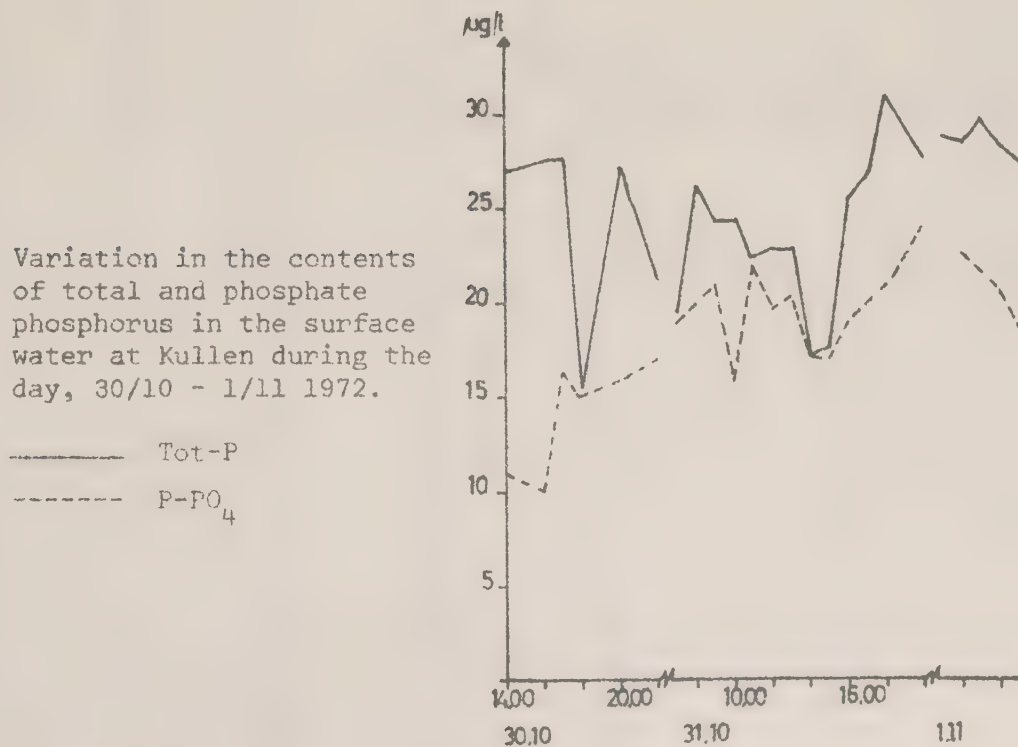


Fig. 44. Mean values of total and phosphate phosphorus of the surface water in near shore areas along the Swedish coast of the Öresund in 1967-72.

----- Tot-P ——— P-PO₄

Fig. 45. Variation in the contents of total and phosphate phosphorus in the surface water at Kullen during the day, 30/10 - 1/11 1972.



——— Tot-P
----- P-PO₄

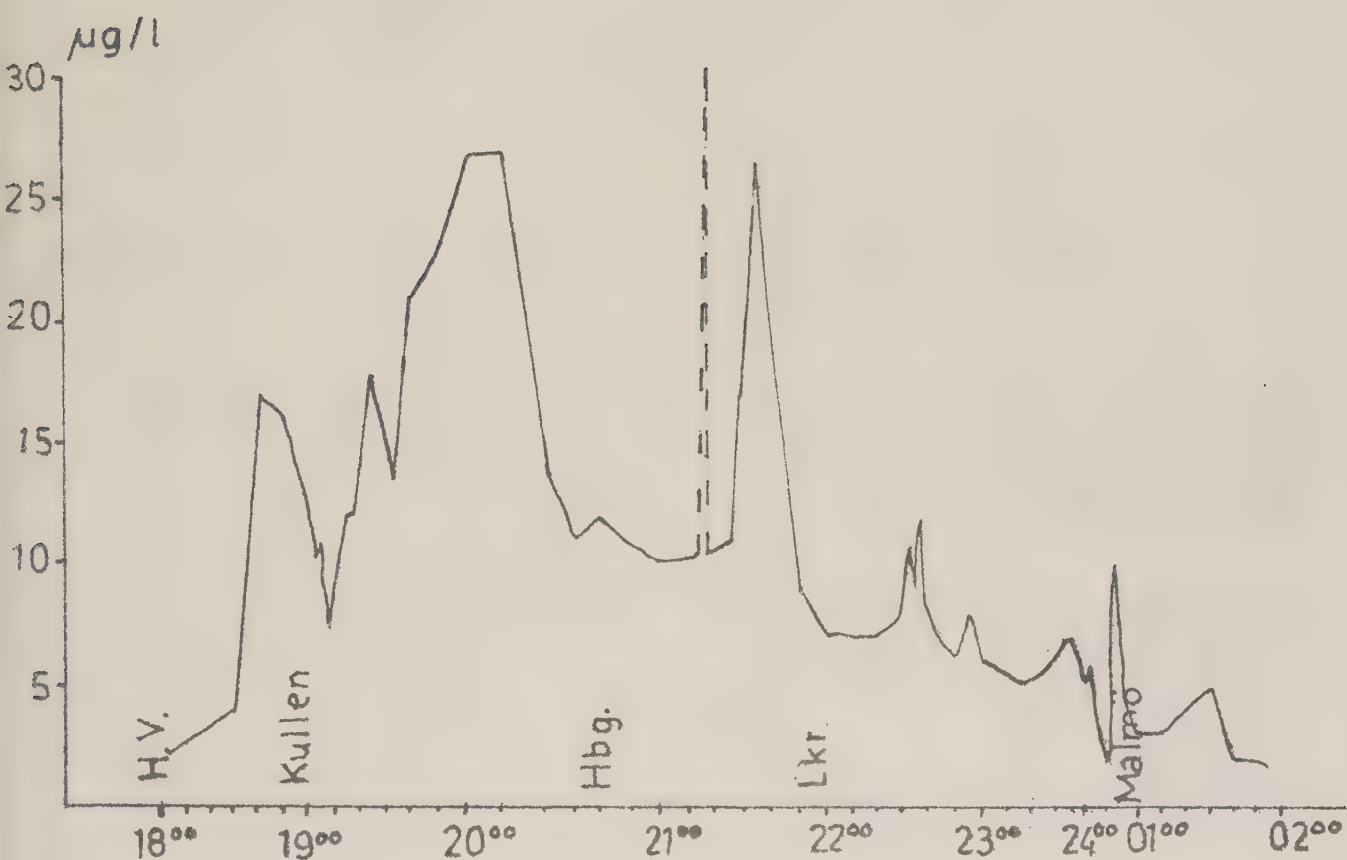


Fig. 47. Variation in the content of phosphate phosphorus in the surface water in the middle of the Öresund from continuous measurements from a ship. Revised from Lindgren (1971).

Fig. 48 A. 10.00

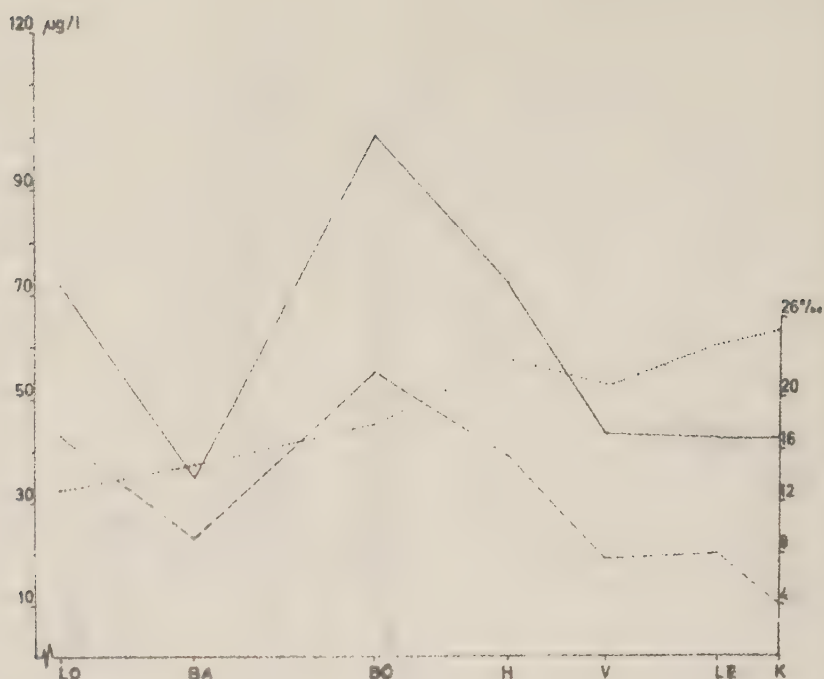


Fig. 48 A - C.

The contents of total and phosphate phosphorus and the salinity in the surface water of 8 different stations at three times of the day, 15/12 1971.

LO = Lomma
 BA = Barsebäck
 BO = Borstahusen
 H = Helsingborg
 V = Viken
 H = Höganäs
 LE = Lerhamn
 K = Kullen

—— Tot-P
 ---- P-PO₄
 S o/oo

Fig. 48 B. 13.00

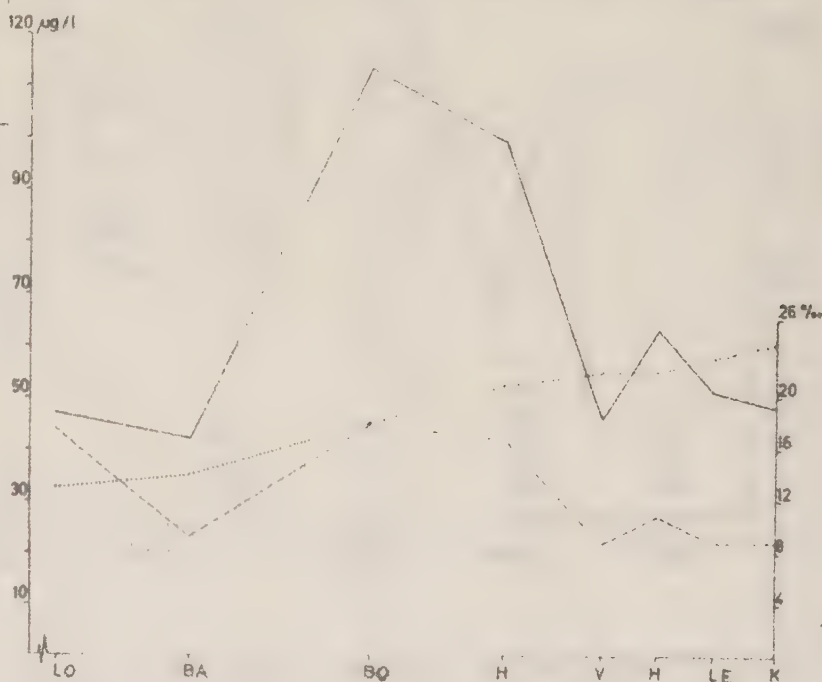
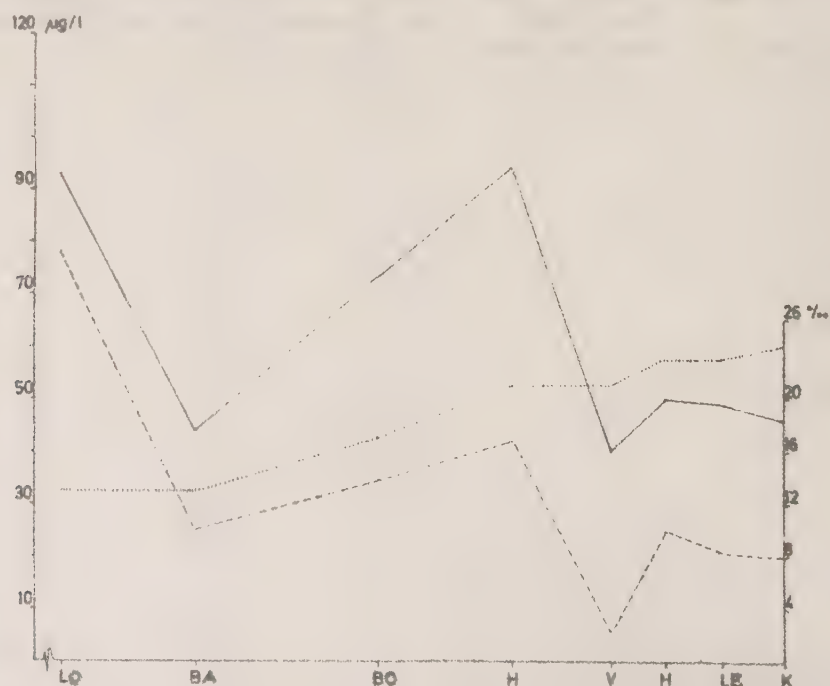


Fig. 48 C. 15.00



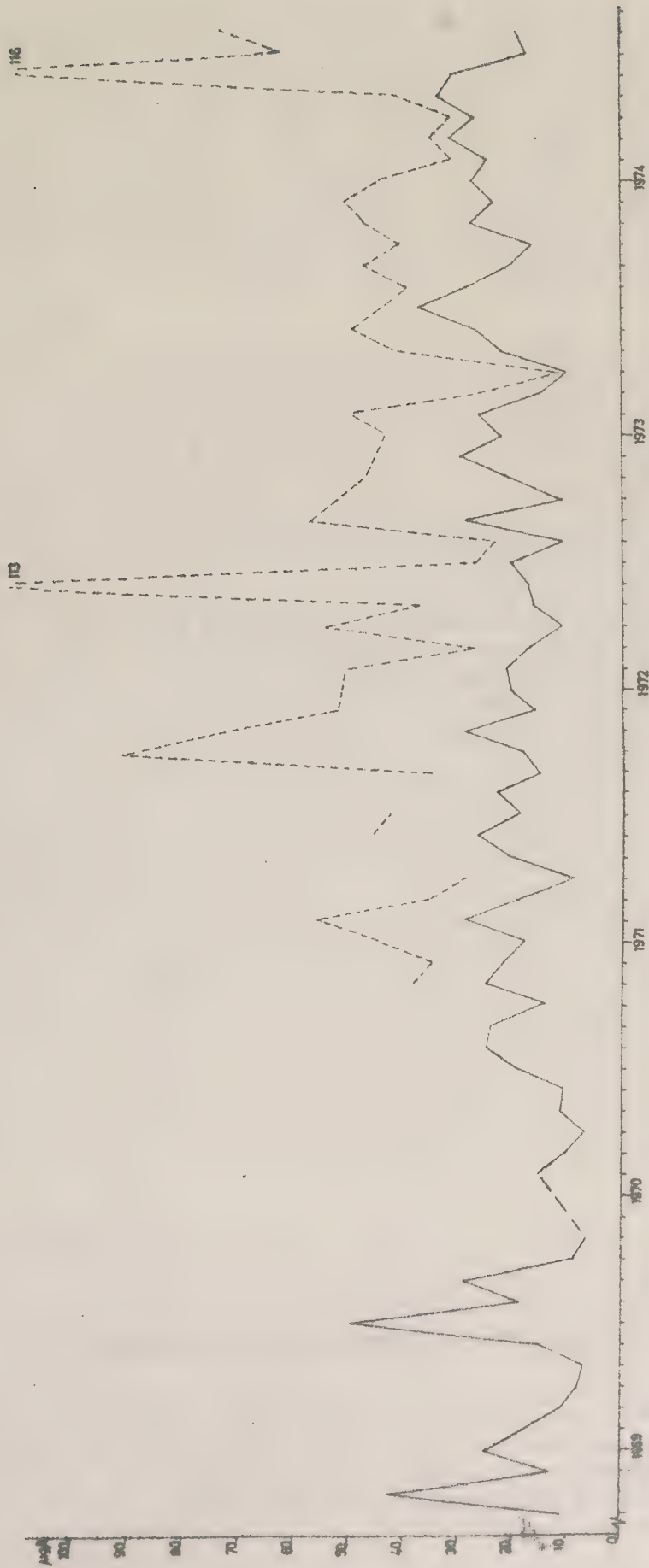


Fig. 49. Monthly mean values of total and phosphate phosphorus in the surface water at Kullen from October 1968 to August 1974. Eight measurements per month. ----- Tot-P ——— P-PO₄

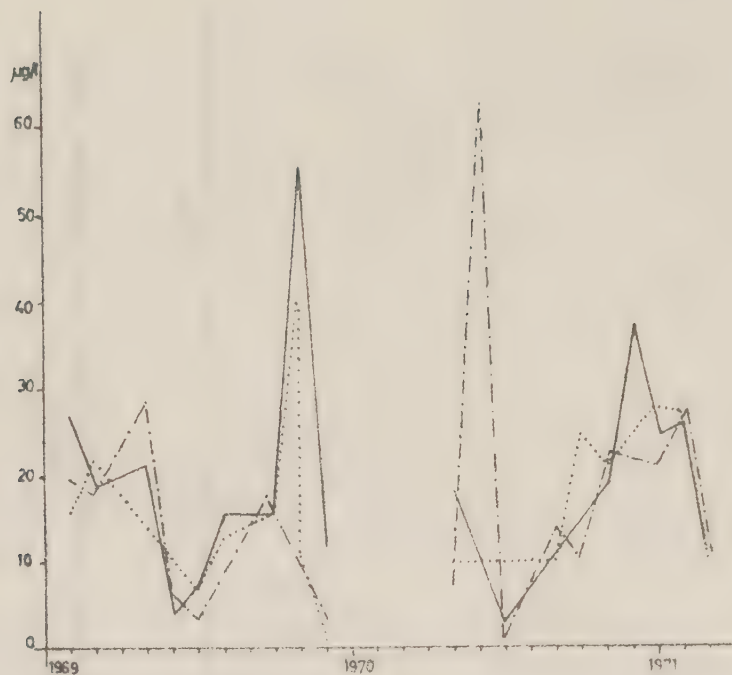


Fig. 50 A. Monthly mean values of phosphate phosphorus at different depths at Lappegrund in 1969-71. Four measurements per month.

----- 0 m 5 m ——— 10 m

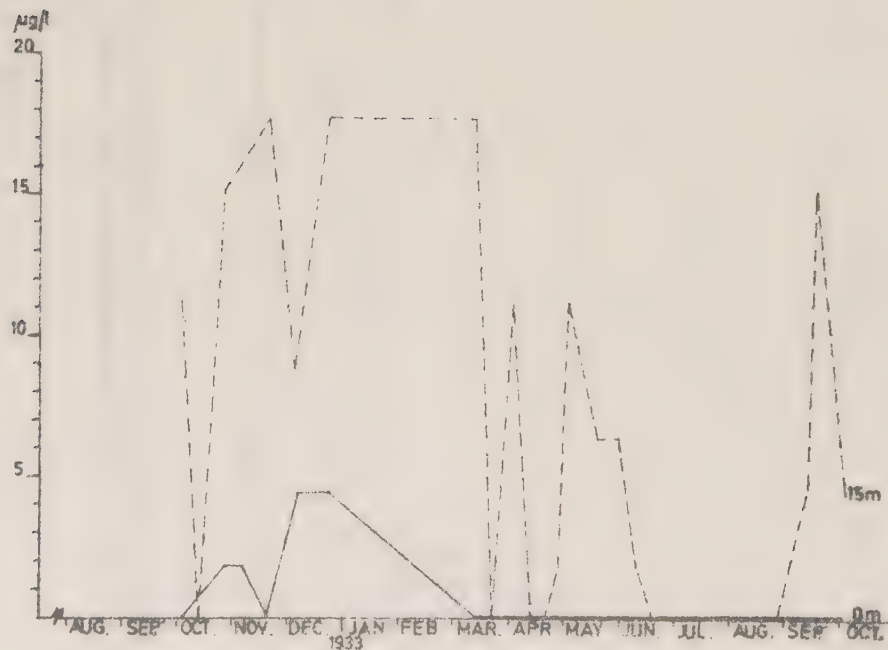


Fig. 50 B. Variation in the content of phosphate phosphorus in the surface water and at 15 m in depth near Helsingör in Oct. 1932 - Oct. 1933. Calculated from Steemann Nielsen (1937).

NITROGEN

For understanding of the nutrient conditions for algal growth in an area it is also essential to know the levels of different nitrogen compounds in the water. The total discharge of nitrogen into the Öresund can be estimated to about 17000 tons per year, from Sweden about 9000 tons per year (Fig. 42).

In the present project, the following nitrogen compounds were analysed in the water samples: nitrate nitrogen (N-NO_3), nitrite nitrogen (N-NO_2), ammonium nitrogen (N-NH_4) and total nitrogen (Tot-N). The analysis methods followed the New Baltic Manual (1972). The nitrate was reduced to nitrite with an amalgamated cadmium column. The measurements were made with a Hitachi 139 spectrophotometer. Except for ammonium about 1500 analyses of each kind have been carried out.

Nitrate nitrogen

There are extremely few previous measurements of nitrate from the area to be used as reference. Steemann Nielsen (1937) gives values from one year. The accuracy of these values is unknown. But knowing that analytical methods used today are not free from errors, it is possible that the values from the 1930s are not quite correct. The magnitude of the values and tendencies in the material, however, ought to be relatively useful. Steemann Nielsen (loc.cit.) found a variation in the surface water of 0 to 40 $\mu\text{g/l}$ and at 15 m in depth of 0 to 60 $\mu\text{g/l}$.

To get a general picture of the nitrate levels in the whole Öresund area, the frequencies of different nitrate nitrogen concentrations at different depths are shown in Fig. 51 A - F. The nitrate nitrogen in the Öresund varies within a broad range, from 0 to 265 $\mu\text{g/l}$ in surface water and from 0 to 170 $\mu\text{g/l}$ at 20 m in depth. Though, for the surface water the greater part of the values lies within 0 to 50 $\mu\text{g/l}$, whereas they for 20 m in depth are more evenly distributed.

In Table 16 are given the concentrations of nitrate nitrogen at different depths for the same four areas as for phosphorus compounds. The table shows that the bottom water in the entire area contains the highest amounts of nitrate nitrogen. When the median values for the surface water in the different areas are compared, it is evident that the Helsingborg-Landskrona area has a higher load of nitrate than the other areas. This impression is enhanced when also the skewness is considered. For 5 - 15 m in depth there is a trend to higher values in the central part of the Öresund than in the northern. The number of measurements from the southernmost part is too small to contribute to the conclusions.

Like for the phosphate and total phosphorus, the concentration of nitrate in the water can change from hour to hour (Fig. 52). Steemann Nielsen (1937) showed a seasonal variation in the content of nitrate near Helsingör. From March to October he could not detect any nitrate in the surface water and from April to August there was no trace of nitrate at 15 m in depth. At the transect from Hornbæk to Viken there is a tendency to lower values of nitrate nitrogen from 5 to 15 m in depth during the vegetation period but the values do not reach zero (Fig. 53 A - E). The data, however, are not yet large enough to permit more general conclusions.

Nitrite nitrogen

There are no previous measurements of nitrite from the Öresund area. The values 0, 107 and 137 $\mu\text{g/l}$, given by Hermann (1967), are apparently incorrect and cannot be used as reference. Braarud & Föyn (1951), who investigated the nitrite concentration in the Oslo Fjord, found nitrite nitrogen levels of 0 - 4 $\mu\text{g/l}$ in relatively unpolluted water and 5 - 64 $\mu\text{g/l}$ for more polluted water.

In the Öresund the nitrite nitrogen concentration varies from 0 to 35 $\mu\text{g/l}$. The values for nitrite nitrogen at different depths in four areas in the Öresund are shown in Table 17. The reliable median values vary between 3.3 and 5.8 $\mu\text{g/l}$ with very small differences between depths. The differences between areas are also small, possibly with a tendency to lower values in the northern area and from 0 to 15 m in depth and higher values between Landskrona and Limhamn at 5 to 15 m in depth.

Also for the nitrite concentration there is a short-term variation but of

minor magnitude (Fig. 52). If there exists a seasonal variation in the content of nitrite is impossible to say for the time being (Fig. 53 A - E).

Ammonium nitrogen

Hermann (1967) found no trace of ammonium in the Öresund. No other references concerning the ammonium levels in the Öresund have been found.

In the present project, relatively few ammonium analyses were made, about 650. The concentration of ammonium nitrogen varies from 0 to 180 $\mu\text{g/l}$. Table 18 shows that the reliable median values vary between 28.0 and 36.7 $\mu\text{g/l}$. The median values differ very little between different depths and areas. However, the values for quartile range seem to be higher in the northern area and the variation breadth tends to be higher in the surface layers.

Total nitrogen

There are no previous total nitrogen measurements available from the area as reference. In the Report of the Fishery Board of Sweden (1972) there are some measurements from the Baltic, which show a variation in the surface water with values from 250 to 400 $\mu\text{g/l}$.

In the Öresund area the amount of total nitrogen in the water varies from 0 to 2700 $\mu\text{g/l}$. Fig. 54 A - F shows the frequencies of different total nitrogen values at different depths in the entire Öresund. In Table 19 is shown how the total nitrogen values are distributed between the different areas and depths. The median values vary from 393 to 767 $\mu\text{g/l}$. In the areas from Kullen to Landskrona the median values decrease with increasing depth, while the area Landskrona-Limhamn shows higher values in the bottom layers. The quartile range decreases towards the bottom in all areas, which indicates that the conditions are more uniform in the bottom water. It is remarkable that the area Helsingborg-Landskrona has lower median values at all depths than the other areas. The quartile ranges, however, are larger.

Like for the other chemical parameters, there is a short-term variation in the total nitrogen concentration even from hour to hour, as exemplified in Fig. 52. The seasonal variation in the total nitrogen content of the surface water has been studied at Kullen since August 1972 (Fig. 55). The monthly mean values vary between 150 and 1100 $\mu\text{g/l}$. There is a tendency to lower values in autumn, probably depending on the wind and current conditions.

Table 16. The concentration of N-NO_3 in $\mu\text{g/l}$ at different depths in four areas in the Öresund in 1972 and 1973.

q_1 q_2 q_3 = quartiles g_1 = skewness n = number of observations
 $q_3 - q_1$ = quartile range R = variation breadth

Area	Depth	q_1	q_2	q_3	$q_3 - q_1$	g_1	R	n
Gilleleje-Kullen to Helsingör-Helsingborg	0 m	5.5	12.1	29.3	23.8	3.01	270	211
	5 m	5.4	11.2	24.0	18.6	2.40	160	94
	10 m	6.3	13.1	20.0	13.7	2.64	190	75
	15 m	8.5	17.0	28.0	19.5	2.32	140	68
	20 m	22.9	36.9	68.8	45.9	1.02	170	103
Helsingör-Helsingborg to Vedbaek-Landskrona	0 m	13.5	33.3	65.7	52.2	0.77	180	180
	5 m	10.0	22.7	46.0	36.0	2.24	210	94
	10 m	13.2	30.0	60.0	46.8	1.19	180	81
	15 m	11.4	24.0	70.0	58.6	1.26	190	64
	20 m	26.8	47.8	127.5	100.7	0.23	180	125
South of Vedbaek-Lands- krona to Dragör-Limhamn	0 m	4.4	8.8	20.6	16.2	2.81	180	175
	5 m	6.9	20.0	40.0	33.1	1.51	150	89
	10 m	8.2	20.0	36.7	28.4	2.02	180	54
	15 m	10.0	23.8	40.0	30.0	2.67	180	26
	20 m	35.0	45.0	60.0	25.0	1.72	150	8
South of Dragör-Limhamn to Falsterbo	0 m	15.0	25.0	40.0	25.0	1.27	90	8
	5 m	20.0	25.0	40.0	20.0	1.12	60	10

Table 17. The concentration of N-NO₂ in $\mu\text{g/l}$ at different depths in four areas in the Öresund in 1972 and 1973.

q_1 q_2 q_3 = quartiles g_1 = skewness n = number of observations
 $q_3 - q_1$ = quartile range R = variation breadth

Area	Depth	q_1	q_2	q_3	$q_3 - q_1$	g_1	R	n
Gilleleje-Kullen to Helsingör-Helsingborg	0 m	1.6	3.3	4.9	3.2	2.24	25	243
	5 m	1.9	3.8	8.2	6.3	1.40	25	99
	10 m	1.8	3.6	6.3	4.5	2.82	30	72
	15 m	1.7	3.4	5.5	3.8	1.71	20	75
	20 m	2.3	4.6	8.1	5.8	0.96	20	115
Helsingör-Helsingborg to Vedbaek-Landskrona	0 m	2.3	4.6	6.8	4.5	1.53	35	116
	5 m	2.1	4.2	8.3	6.2	1.17	20	97
	10 m	2.3	4.7	8.3	6.0	1.11	20	81
	15 m	2.0	4.1	7.6	5.7	1.46	20	69
	20 m	2.1	4.2	7.9	5.8	1.34	20	135
South of Vedbaek-Lands- krona to Dragör-Limhamn	0 m	1.9	3.8	6.7	4.8	2.34	30	167
	5 m	2.9	5.8	9.4	6.4	1.48	30	86
	10 m	2.9	5.8	8.5	5.6	1.39	25	59
	15 m	2.6	5.0	8.5	5.8	1.09	20	34
	20 m	5.0	7.0	9.0	4.0	0.03	15	8
South of Dragör-Limhamn to Falsterbo	0 m	1.7	4.2	7.5	5.8	1.75	20	9
	5 m	5.0	10.0	17.5	12.5	-0.22	20	4

Table 18. The concentration of N-NH_4 in $\mu\text{g/l}$ at different depths in four areas in the Öresund in 1972 and 1973.

q_1 q_2 q_3 = quartiles g_1 = skewness n = number of obser-
 $q_3 - q_1$ = quartile range R = variation breadth vations

Area	Depth	q_1	q_2	q_3	$q_3 - q_1$	g_1	R	n
Gilleleje-Kullen to Helsingör-Helsingborg	0 m	22.2	35.0	52.5	30.3	1.82	170	83
	5 m	24.2	34.0	70.0	45.8	1.21	160	36
	10 m	23.3	34.0	56.7	33.3	0.82	100	18
	15 m	20.0	33.3	70.0	50.0	1.04	110	18
	20 m	25.0	30.0	37.5	12.5	0.00	40	50
Helsingör-Helsingborg to Vedbaek-Landskrona	0 m	19.4	32.7	47.1	27.7	1.39	120	62
	5 m	21.8	33.8	46.2	24.4	1.90	150	55
	10 m	23.6	32.3	41.4	17.9	1.67	110	47
	15 m	18.9	28.9	47.5	28.6	0.90	90	33
	20 m	17.7	28.0	42.0	24.3	1.40	110	60
South of Vedbaek-Lands- krona to Dragör-Limhamn	0 m	26.9	36.7	53.3	26.4	1.18	110	58
	5 m	24.6	34.6	46.7	22.1	1.05	90	50
	10 m	20.0	30.0	45.0	25.0	1.31	110	31
	15 m	22.0	30.0	46.7	24.7	1.09	90	18
	20 m	25.0	30.0	36.7	11.7	-0.62	40	6
South of Dragör-Limhamn to Falsterbo	0 m	40.0	76.7	100.0	60.0	0.16	140	9
	5 m	10.0	33.3	40.0	30.0	0.21	70	8

Table 19. The concentration of total nitrogen in $\mu\text{g/l}$ at different depths in four areas in the Öresund in 1972 and 1973.

q_1 q_2 q_3 = quartiles g_1 = skewness n = number of obser-
 $q_3 - q_1$ = quartile range R = variation breadth vations

Area	Depth	q_1	q_2	q_3	$q_3 - q_1$	g_1	R	n
Gilleleje-Kullen to Helsingör-Helsingborg	0 m	380	723	955	575	0.23	2200	316
	5 m	375	560	850	475	1.94	2700	89
	10 m	392	546	811	419	1.66	2100	68
	15 m	362	533	800	438	0.86	1400	67
	20 m	392	577	810	418	0.39	1300	92
Helsingör-Helsingborg to Vedbaek-Landskrona	0 m	254	522	888	634	0.74	2000	105
	5 m	253	462	820	567	1.05	2000	99
	10 m	314	433	820	506	0.78	1700	82
	15 m	283	483	867	583	1.73	1800	66
	20 m	209	393	742	533	1.19	1800	135
South of Vedbaek-Lands- krona to Dragör-Limhamn	0 m	368	631	935	567	0.19	1300	181
	5 m	379	592	812	434	0.52	1500	91
	10 m	364	600	817	452	0.98	1700	59
	15 m	629	767	888	259	0.07	1000	30
	20 m	650	750	800	150	0.32	500	7
South of Dragör-Limhamn to Falsterbo	0 m	300	600	1467	1167	0.32	1800	17
	5 m	450	600	1450	1000	-0.04	1500	10

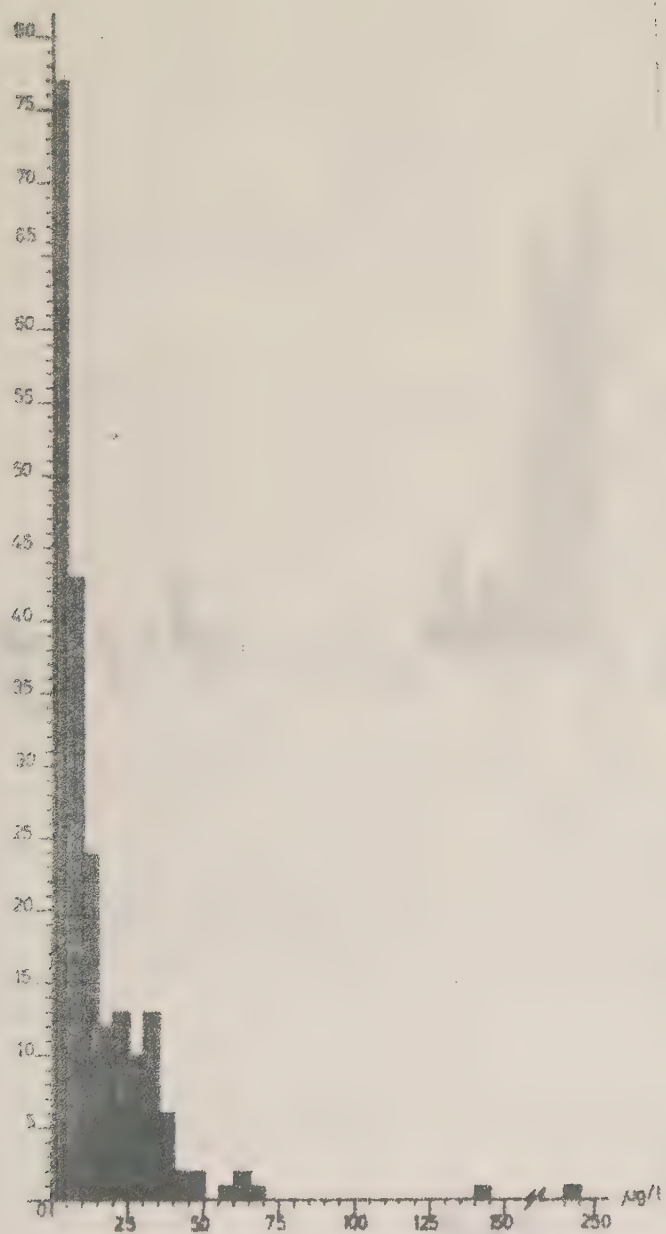


Fig. 51 A. Surface water at stations less than 5 m in depth.

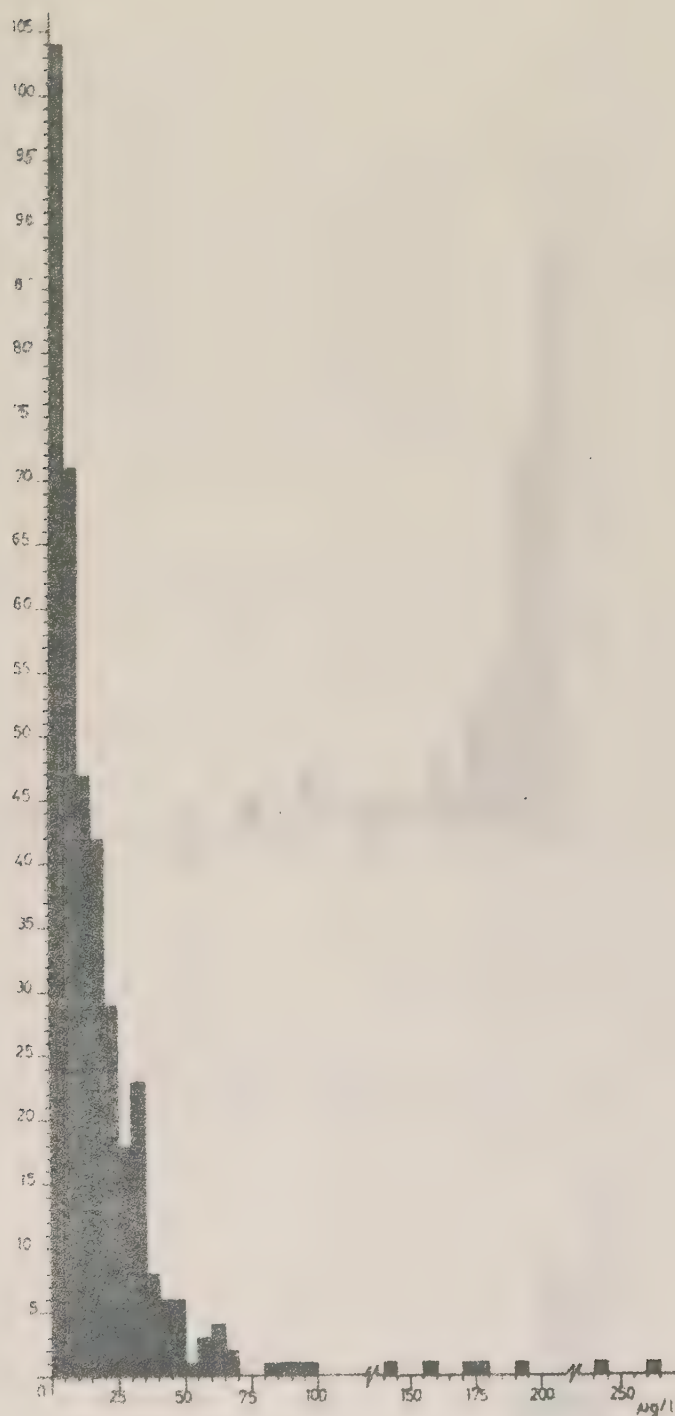


Fig. 51 B. Surface water at stations more than 5 m in depth.

Fig. 51 A - F. Frequencies of the content of nitrate nitrogen at different depths in the Öresund in 1972.

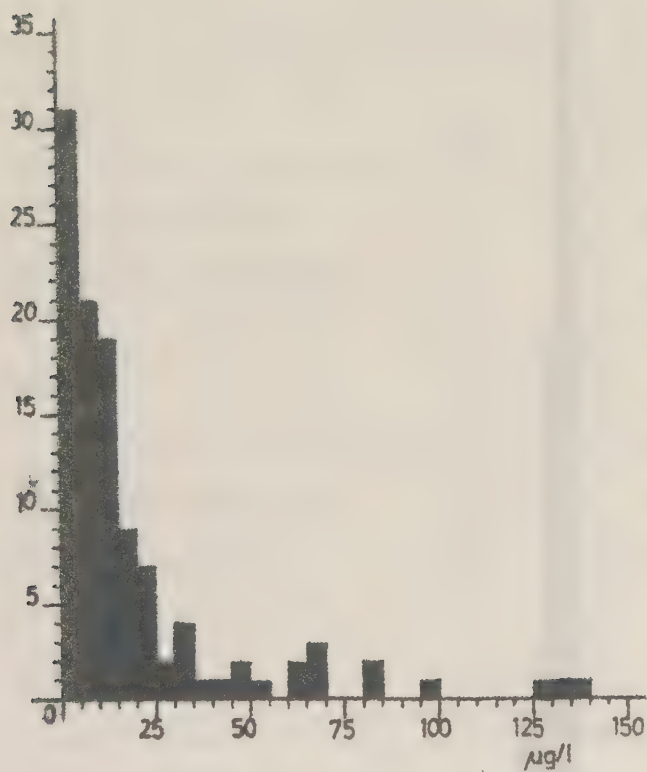


Fig. 51 C. 5 m.

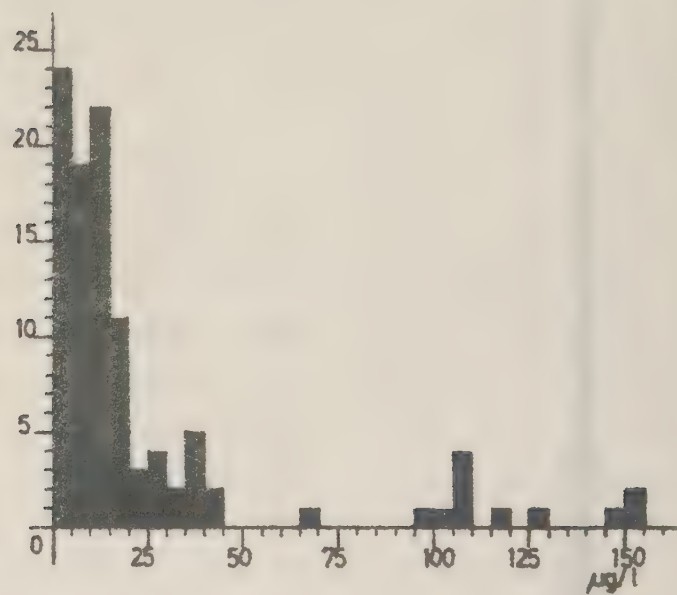


Fig. 51 D. 10 m.

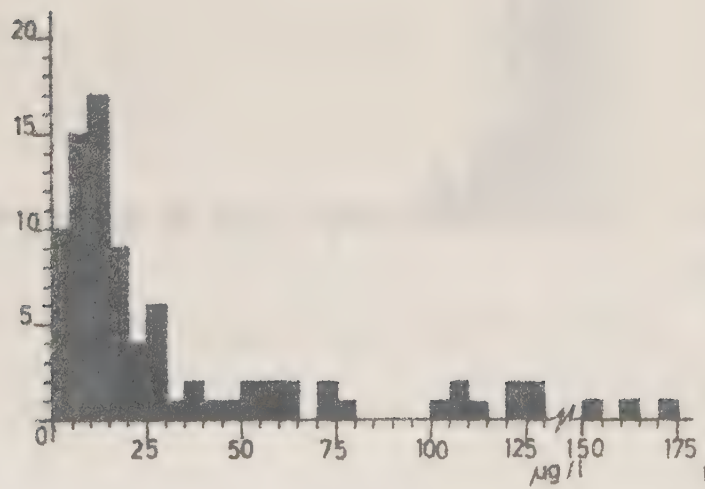


Fig. 51 E. 15 m.

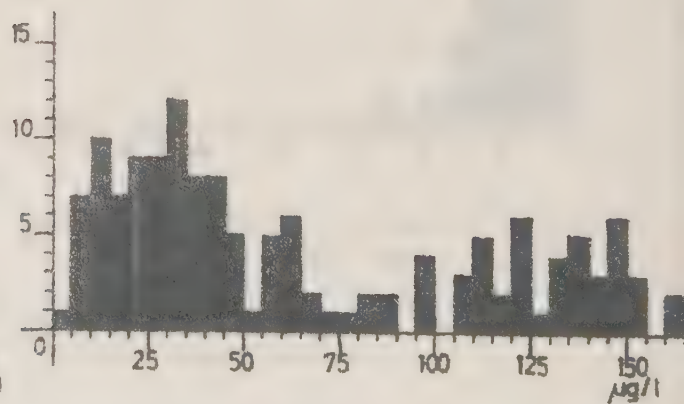


Fig. 51 F. 20 m.

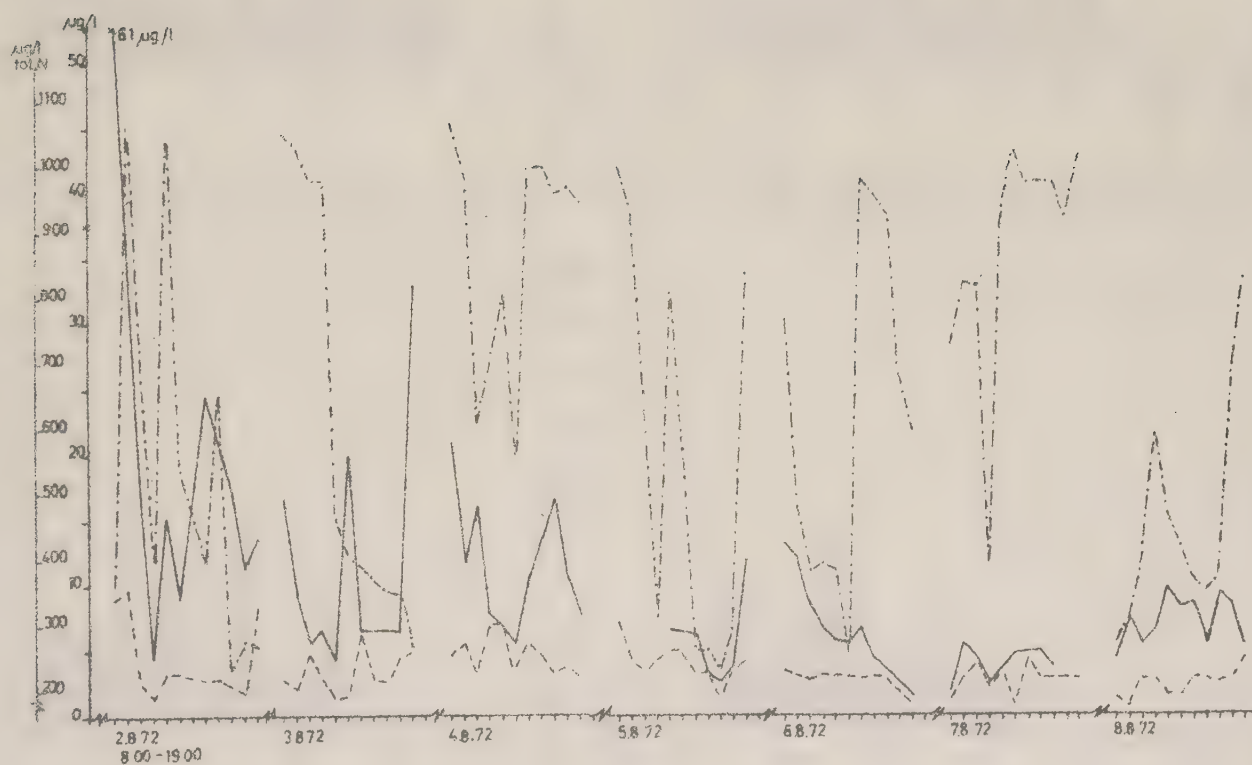


Fig. 52. Variation in the contents of total, nitrate and nitrite nitrogen in the surface water at Barsebäck during the day, 2/8 - 8/8 1972:

..... Tot-N _____ N-NO₃ - - - - - N-NO₂

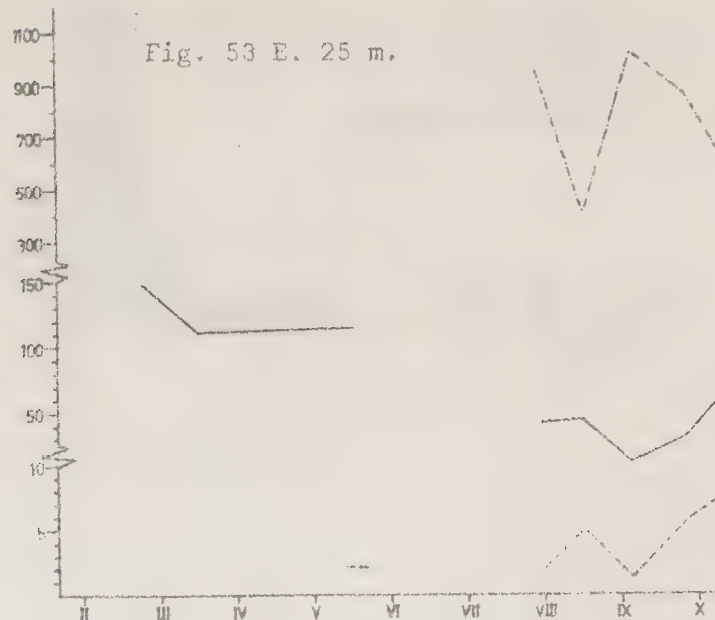
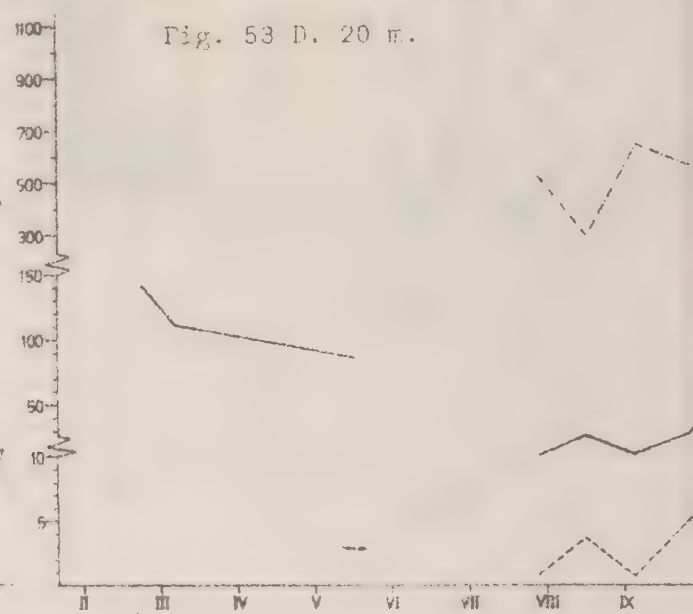
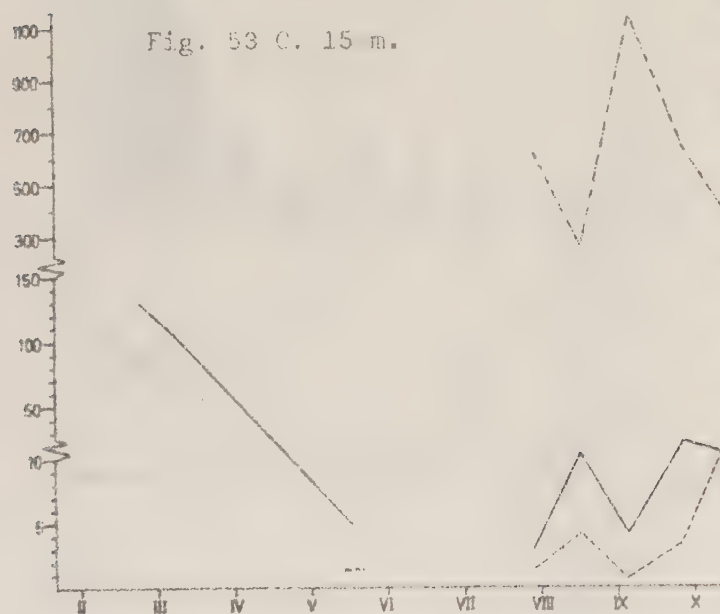
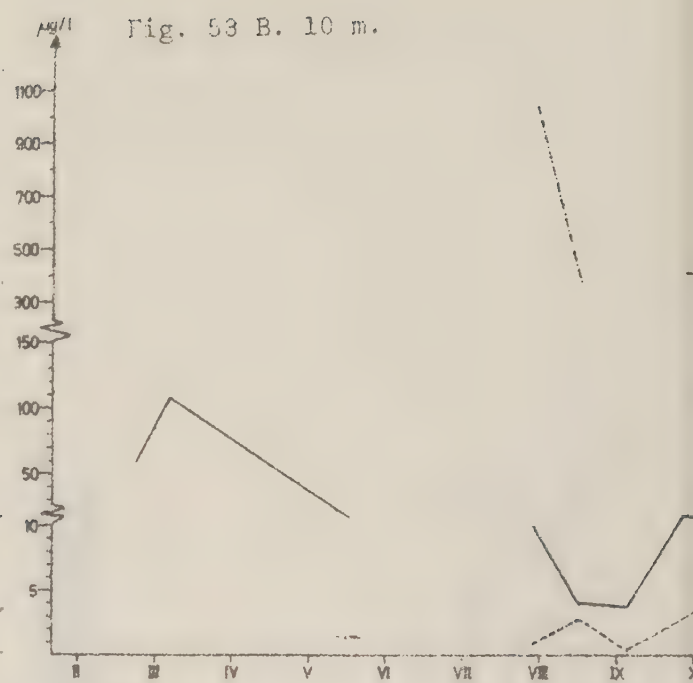
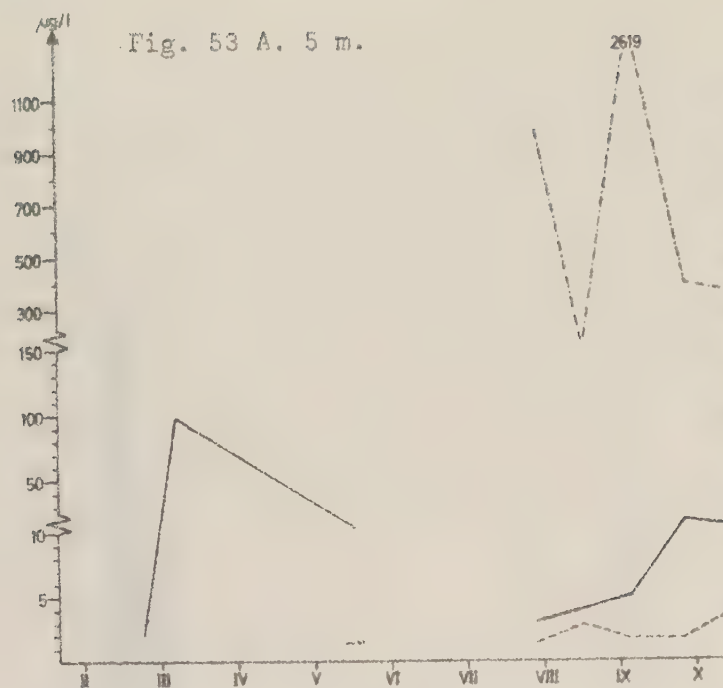


Fig. 53 A - E.

Seasonal variation in the contents of total, nitrate and nitrite nitrogen at different depths at station 2 on the transect Hornbaek - Viken in 1972.

--- Tot-N
 — N-NO₃
 - - - N-NO₂

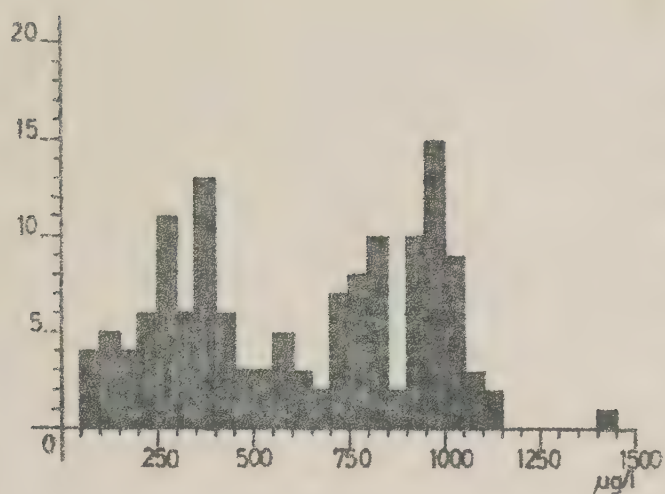


Fig. 54 A. Surface water at stations less than 5 m in depth.

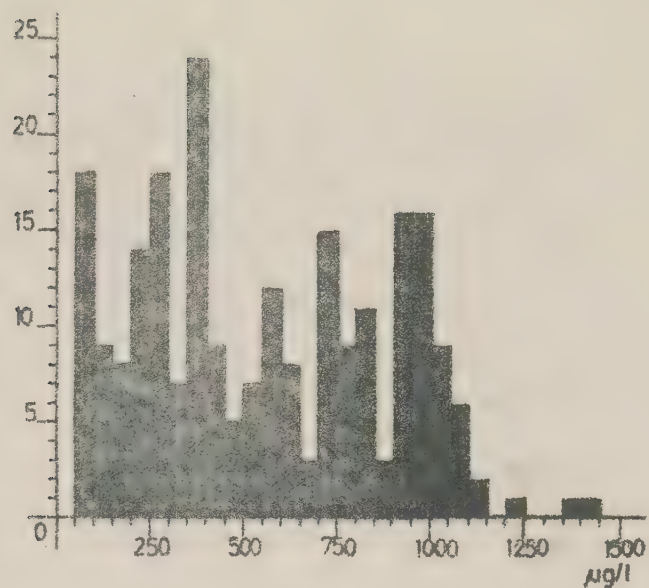


Fig. 54 B. Surface water at stations more than 5 m in depth.

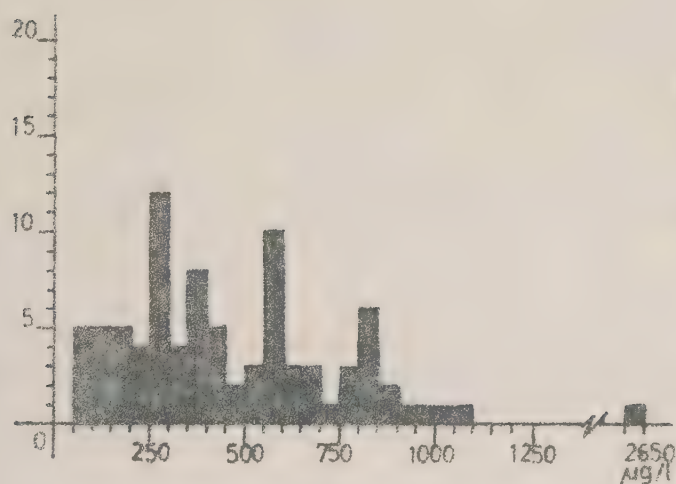


Fig. 54 C. 5 m.

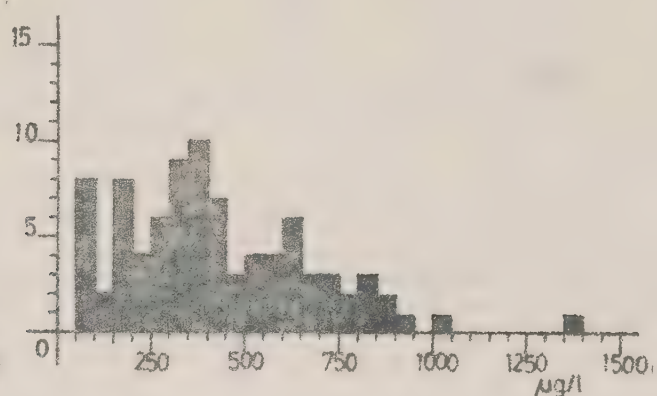


Fig. 54 D. 10 m.

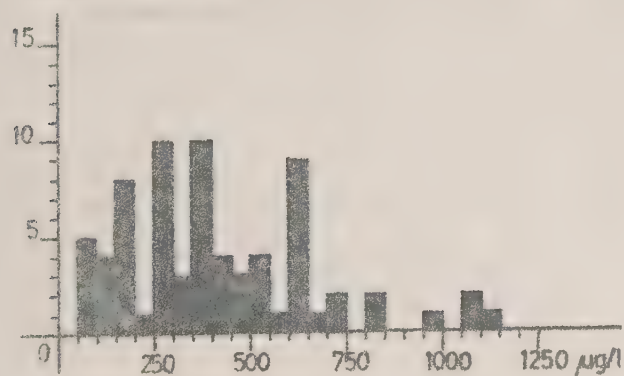


Fig. 54 E. 15 m.

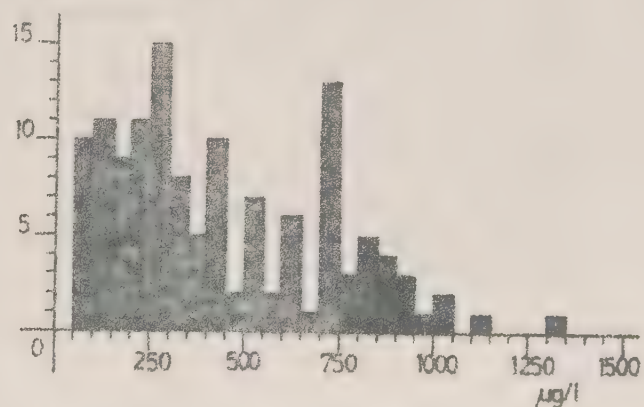


Fig. 54 F. 20 m.

Fig. 54 A - F. Frequencies of the content of total nitrogen at different depths in the Öresund in 1972.



Fig. 55. Monthly mean values of total nitrogen in the surface water at Kullen from August 1972 to November 1974. Eight measurements per month.

TRACE ELEMENTS

The content of trace elements in sea water has gained interest during the last decade, due among other things to the potential danger of toxic effects of pollution on marine organisms. Unfortunately, there are no previous analyses in this field from the Scandinavian waters except by Sen Gupta (1972) and Hägerhäll (1973). The latter made a more detailed investigation of the trace element situation in the Öresund.

The normal content of trace elements in sea water is, according to Goldberg (1965), very low. However, conditions in coastal waters are more variable. The average values for such areas may be 3 - 5 $\mu\text{g Cu/l}$, 10 - 20 $\mu\text{g Zn/l}$, 0.2 $\mu\text{g Pb/l}$ and 0 - 0.2 $\mu\text{g Cd/l}$ (Hägerhäll, loc.cit.). According to Hägerhäll the water of the Öresund area can be divided into three types regarding its trace element content:

1. Waters with trace element contents that are normal for coastal waters and where increased concentrations are found very sparsely (northwestern part of the Öresund and south of Skanör - Köge).
2. Waters that mostly have a normal content of trace elements but where raised concentrations occur regularly (most parts of the Öresund).
3. Waters where high concentrations are always found (outside Helsingborg, Landskrona, Copenhagen, Malmö and in Lomma Bay). Concentrations of about 100 $\mu\text{g/l}$ for copper, lead and zinc were measured frequently in this type of water.

Methods: Analyses of water samples concerning the concentration of cadmium, copper, lead and zinc were made according to Brooks, Presley & Kaplan (1967), where the trace elements are transferred to an organic phase with MIBK - APDC. The measurements were carried out with a Perkin Elmer 306 atomic absorption spectrophotometer.

About 1000 analyses of water samples concerning the levels of cadmium, copper, lead and zinc have been performed in the present project. The samples were mainly taken from Lomma Bay, a transect between Barsebäck and Skogshoved and the Hornbaek - Viken transect.

The amount of trace elements in Lomma Bay can vary considerably from normal values to very high. Low values are found in connection with high salinity. The high levels of trace elements occur after recirculation of the water within the bay for some time (cf. Fig. 31). In Figs. 56 and 57 and Table 20 are given examples of the distribution of high levels of copper and lead in Lomma Bay at such occasions. The maximum values were for copper 125 $\mu\text{g/l}$ and for lead 146 $\mu\text{g/l}$. When the wind and current directions change, the water mass of Lomma Bay may move northward and cause a sudden increase of trace element contents in adjacent areas. Such phenomenon is regularly met with at e.g. Barsebäck (Fig. 58 and Table 21).

In most cases high levels of each trace element occur simultaneously but sometimes other distribution patterns are observed. Table 22 show one occasion at a transect between Barsebäck and Skogshoved with very low values of copper and zinc, combined with high levels of lead and cadmium.

Also in the northern part of the Öresund, where the amounts of trace elements as a rule are smaller, the metals are not evenly distributed in the water column. Along the transect Hornbaek - Viken different types of distribution pattern are distinguished. Higher values of e.g. cadmium may be found in the coastal areas (Figs. 59 A - B, 60 and 61), in the central part (Fig. 59 C) or in the halocline (Fig. 59 D).

Table 20. The concentration of lead in $\mu\text{g/l}$ at different stations and depths in Lomma Bay 15/5 1970. The location of the sampling stations is shown in Fig. 56 A.

Depth in m	A1	A2	A3	A4	A5	
0	42	42	83	104	104	$\mu\text{g/l}$
2.5	83	125	42	62	125	
5	42	146	62	62	62	
10	104	62	83	-	125	
12.5	-	-	104	125	42	

Depth in m	B1	B2	B3	B4	B5	
0	104	104	83	42	42	$\mu\text{g/l}$
2.5	62	42	42	125	125	
5	62	62	104	104	42	
10	83	125	-	21	83	

Depth in m		C2	C3	C4	C5	
0		125	83	104	83	$\mu\text{g/l}$
2.5		21	10	83	104	
5		42	125	83	83	
10		42	42	-	-	

Table 21. Hourly variation in the concentration of zinc in the surface water at Barsebäck 18/8 - 21/8 1970.

18/8												
Hour				11			14					
$\mu\text{g/l}$				48			42					

19/8												
Hour	08	09	10	11	12	13	14	15	16	17		19
$\mu\text{g/l}$	80	20	46	86	42	44	46	38	40	48		23

20/8												
Hour		09	10			13	14	15	16	17	18	19
$\mu\text{g/l}$		100	36			38	100	100	96	46	44	49

21/8												
Hour	07	08		10	11	12	13	14	15		17	
$\mu\text{g/l}$	60	80		50	96	50	50	50	80		44	

Table 22. The concentration of copper, zinc, lead and cadmium in $\mu\text{g/l}$ at different stations and depths along a transect between Barsebäck and Skogshoved 15/11 1974.

Station	Depth in m	Cu	Zn	Pb	Cd in $\mu\text{g/l}$
1 (east of Skogshoved)	0	0.8	40	3.4	1.4
	5	3.3	45	6.2	1.5
	10	1.2	40	5.3	1.2
	15	2.5	41	3.4	1.5
2	0	3.5	110	3.4	3.2
	5	1.2	0	1.4	4.1
	10	1.2	0	1.8	0.6
	15	0.6	0	1.4	1.1
3	0	1.9	54	4.8	1.5
	5	1.7	44	4.4	2.6
	10	1.2	40	3.4	0.8
	15	1.7	44	1.6	0.8
4	0	3.1	0	1.8	1.8
	5	0.8	0	2.0	2.0
	10	1.7	42	2.5	5.2
	15	1.9	0	1.4	0.2
	20	1.9	48	2.5	1.0
5 (west of Barsebäck)	0	2.0	0	3.5	1.0
	5	1.3	45	1.8	1.8
	10	1.1	0	2.0	1.4



Fig. 56 A. Map of sampling stations in Lomma Bay.



Fig. 56 B. In the surface water.

Fig. 56 A - E. The Cu-concentration in $\mu\text{g/l}$ in Lomma Bay 15/5 1970. From v. Wachenfeldt (1971).

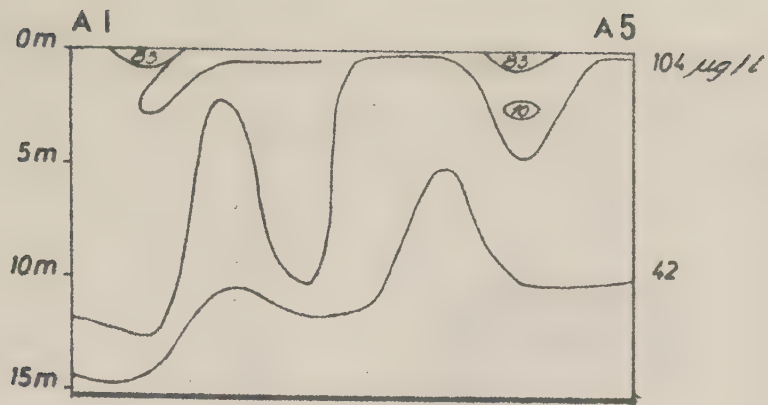


Fig. 56 C. At a transect between station A1 and A5.

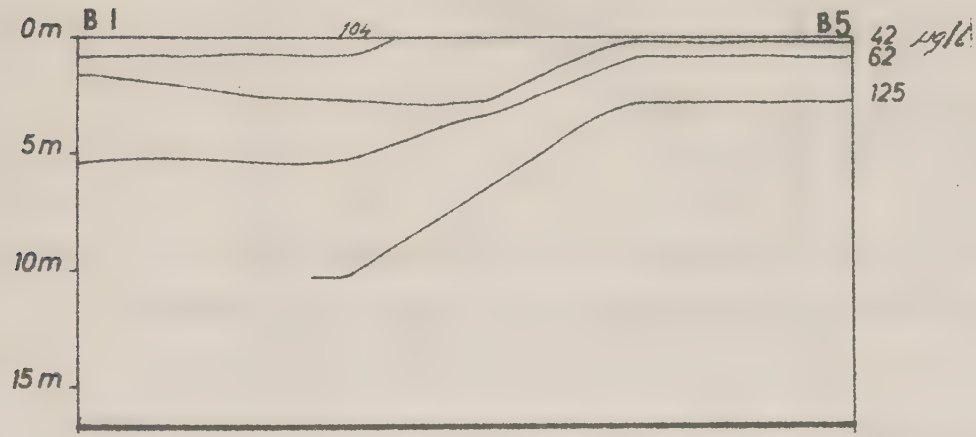


Fig. 56 D. At a transect between station B1 and B5.

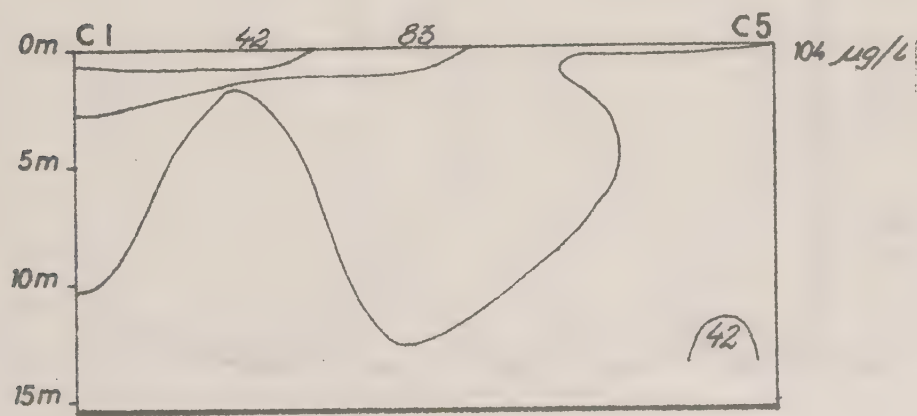


Fig. 56 E. At a transect between station C1 and C5.

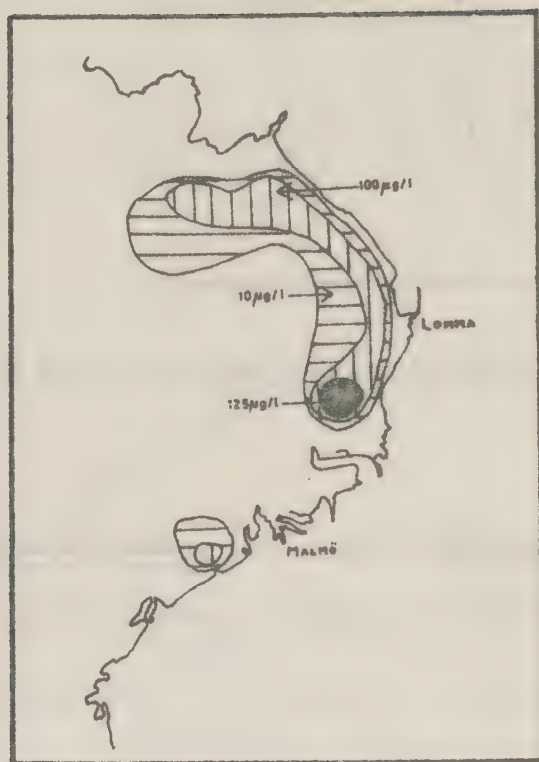


Fig. 57. The Cu-concentration in µg/l of the surface water in Lomma Bay and south of Malmö 24/4 1968. From v. Wachenfeldt (1971).

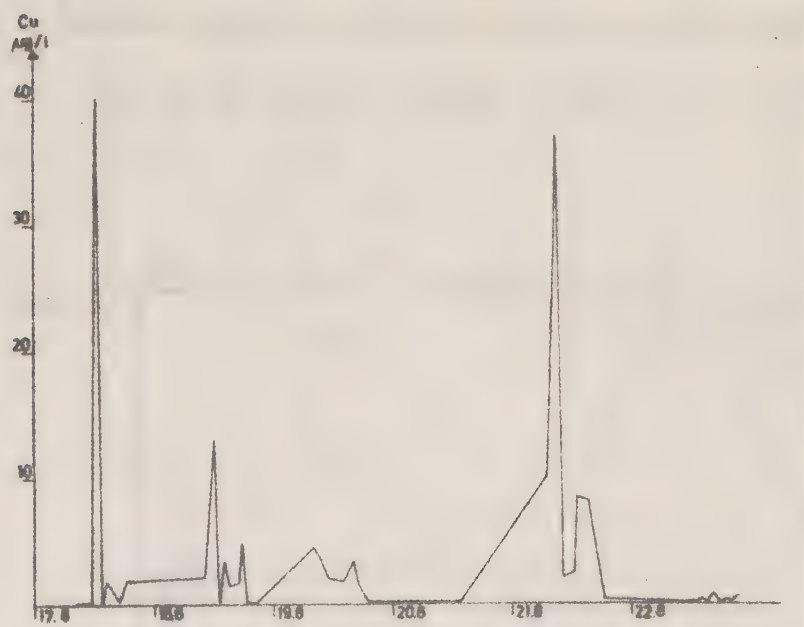


Fig. 58. Variation in the Cu-concentration of the surface water at Barsebäck, measured every hour from 17/8 to 22/8 1971. From v. Wachenfeldt (1971).

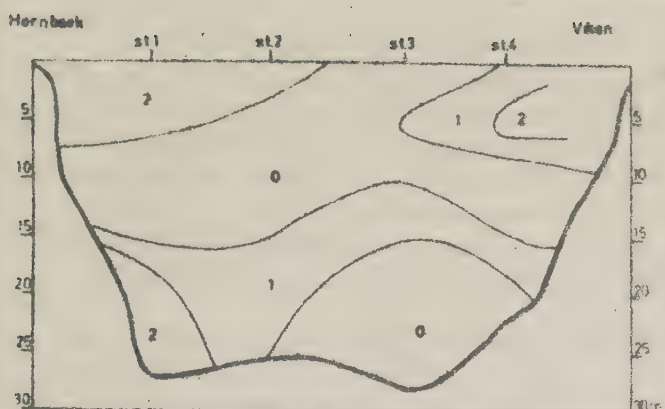


Fig. 59 A. Cd 11/10 1972.

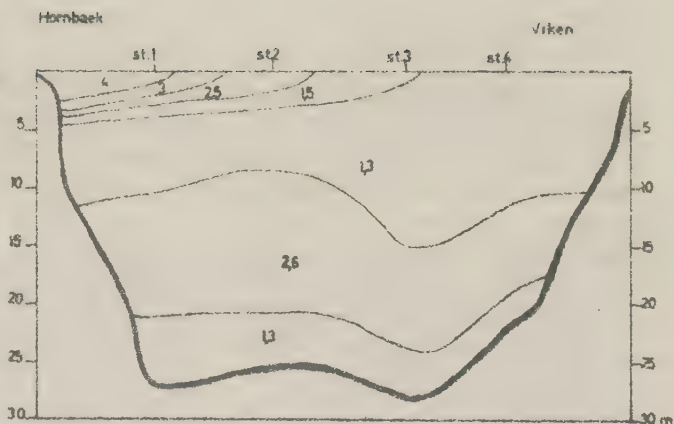


Fig. 59 B. Cd 5/4 1974.

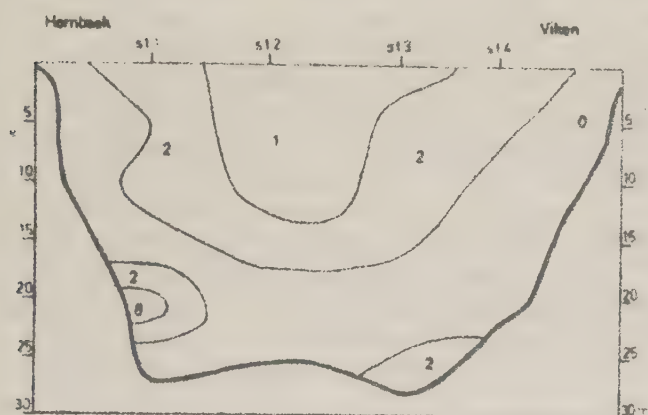


Fig. 59 C. Cd 3/5 1972.

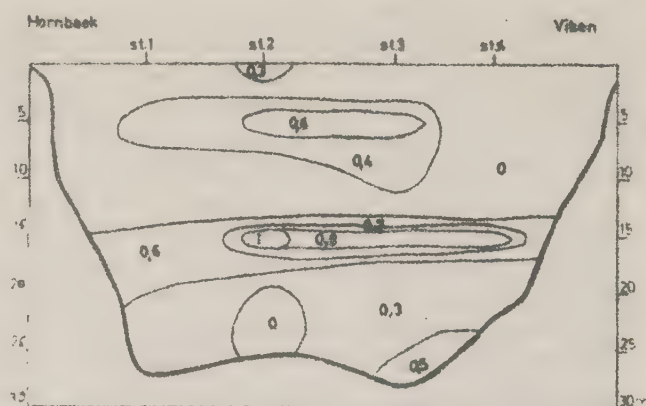


Fig. 59 D. Cd 15/8 1972.

Fig. 59 A - D. The distribution of cadmium ($\mu\text{g/l}$) at the Hornbaek-Viken transect.

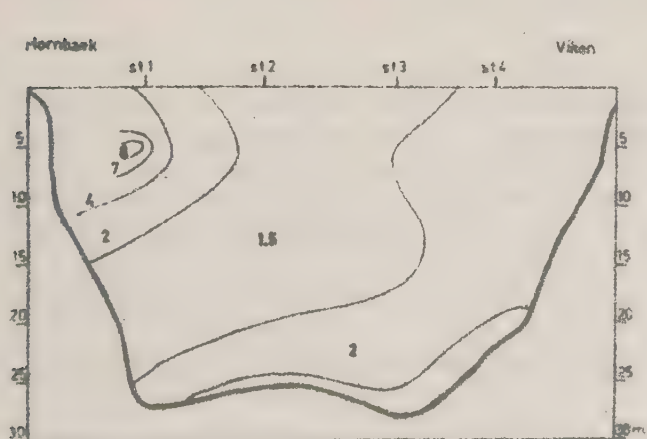


Fig. 60. The distribution of Cu ($\mu\text{g/l}$) at the Hornbaek-Viken transect 15/8 1972.

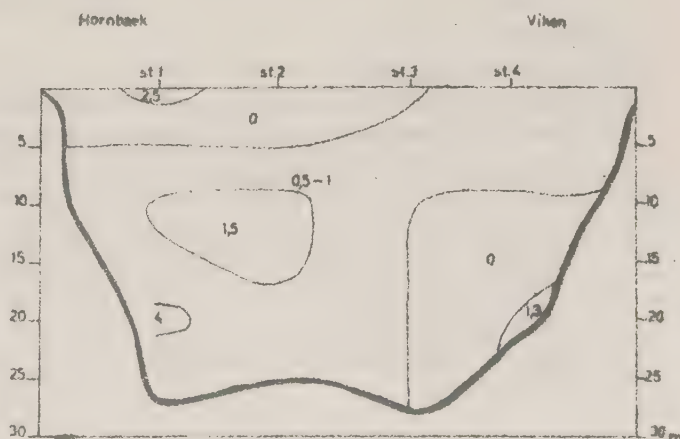


Fig. 61. The distribution of Pb ($\mu\text{g/l}$) at the Hornbaek-Viken transect 8/11 1974.

YELLOW SUBSTANCE

Jerlov (1955) showed that there is a good correlation between the amount of yellow substance and the salinity. Thus, the low-saline water of the Baltic has a high amount of yellow substance and the more saline water of Kattegatt has low values. According to Jerlov (loc.cit.) the values for the Öresund area should vary from $0.45-0.65 \text{ m}^{-1}$ (Fig. 62 A). The measurements along the Swedish coast were repeated by Bladh (1972) who showed that the values had probably increased since Jerlov's investigation in 1953 and gave a variation of 0.50 to 0.85 m^{-1} from the Öresund (Fig. 62 A).

The analyses of yellow substance were performed in the present project according to the method of Jerlov (loc.cit.), using a Hitachi 139 spectrophotometer with 5 cm cells. Until now about 1000 analyses have been made.

The values from the Öresund show that the amount of yellow substance, including other organic compounds which absorb light at 380 nm, varies within a broad interval. A closer analysis of the data shows that there seems to be values higher than normal near the shore and in shallow water, e.g. in the vicinity of Helsingborg and Landskrona and in Lomma Bay. Higher values have also been obtained in the halocline. South-going currents and N-NNW-NW winds give normal values while north-going currents and S-SW winds give higher values.

The values for the amount of yellow substance from the entire Öresund area in 1972 are plotted against salinity in Fig. 62 A. The values for the lowest and highest salinity are 1.85 and 1.50. Compared with Jerlov's (1955) measurements, the values are considerably higher. When the corresponding values for the northern part of the area (Hornbæk - Viken) are calculated (Fig. 62 B), one gets a range from 1.45 to 0.65. The difference between the obtained higher values and the expected normal values could be considered as a measure of the load of organic compounds, which emanate from sewage outlets and from decaying products of the increased algal production.

LIGHT CONDITIONS

When estimating the algal growth and production in the sea and studying the vertical distribution of the algae, it is essential to know the light conditions, e.g. the spectral composition and the available light energy at different depths. Unfortunately, there is very little information about the light conditions in Öresund area. It would have been of great interest to know if and how the light conditions have changed since the beginning of this century, when i.a. Rosenvinge made his algal collections in the area.

Methods:

1. Secchi disc measurements were made according to standard procedure.
2. Downward irradiance has been measured with a submarine photometer with a selenium photovoltaic cell in a water-tight housing. Schott & Genossen filters of 380, 525 and 625 nm were used, always with an opal glass and sometimes together with a neutral filter, ON 31 or ON 32. Measurements with the different filters were first made in the air above the surface, then at every metre down to 20 - 25 m and ending with a new measurement in the air.
3. For beam transmittance measurements a transmittance meter, constructed by Jerlov, was used.
4. Quanta measurements were made with a quantaspectrometer QSM 24, constructed by Halldal.

Secchi disc measurements

The terminology for measurements with Secchi discs is unstable. Harvey (1966) uses the term light absorption and Söderström (1971) transparency. In other literature one can find other terms, including transmission measurements. The only reference in literature to the conditions in the Öresund is a vague statement by Brattström (1941), who says "aus eigener Erfahrung weiss ich, dass Gegenstände auf dem Grunde selten in mehr als 8 - 9 m Tiefe zu sehen sind, oft nicht einmal in dieser Tiefe".

About 500 Secchi disc measurements, scattered in the entire Öresund area, were performed in this project. The greatest part of them lies between 6.0 and 6.5 m. After persistent N-NW winds 7.0 to 7.5 m have been recorded and on some rare occasions, especially during the spring with strong north-going currents and southerly winds, 11 to 12 m. From the few statements in earlier reports, it is not possible to say if there really has been an increase in the particle content of the water and a subsequent effect of the primary production.

Downward irradiance

The only work dealing with downward irradiance in the Öresund is that of Steemann Nielsen & Hansen (1961), who give values for the conditions of green light only. When performing downward irradiance measurements one has, according to Jerlov (1970), to pay attention "to the bandwidth error which occurs with broad filters, and which is caused by a change in the width of the transmitted band and its position in the spectrum on account of the wavelength selective absorption by the water". This is true, especially with the red and violet filters; the bandwidth and the optical mean value change towards green with increasing depth.

About 250 series of downward irradiance measurements have been made in the Öresund area. In Fig. 63 A - B are shown two types of common situations. The largest difference between them is the attenuation in blue light. The 1 % level of downward irradiance is in one case reached at about 12 m in depth and in the other at only about 4 m. Intermediate types occur but the two above pictured seem to be in majority.

For comparison, measurements have been performed both in the Baltic proper (Fig. 64), which has relatively high amounts of yellow substance (0.92 m^{-1}) and in Kattegatt (Fig. 65 A - B), which has a low level of yellow substance ($0.4 - 0.1 \text{ m}^{-1}$). In the Baltic the 1 % level is reached at 7.5 m for blue light, at 16 m for green light and 10 m for red light. The corresponding values for the measurements in Kattegatt are 14-22 m for blue light and 10.5-13.5 m for red light.

The gradual increase in downward irradiance for blue light from Helsingborg and northward at the same occasion is shown in Fig. 66 A - C. At Helsingborg the 1 % level for blue light is reached at about 9 m, at Kullen at about 15 m and in southern Kattegatt (off Hesselö) at about 18 m in depth.

The 5 % and 1 % levels of downward irradiance for localities from different areas are given in Table 23.

Table 23. Depth in m for the 5 % and 1 % levels of downward irradiance at localities in the Baltic, Öresund and Kattegatt.

Area	Locality	5 % level			1 % level		
		Blue	Green	Red	Blue	Green	Red
The Baltic	Hanö Bay	4.5	10.5	7	7.5	16 ¹	10
Öresund	Copenhagen	3	12	6	4	20 ¹	12 ¹
"	Ven	8	18	8	12	26 ¹	12
"	Helsingborg	6		6	9 ¹		9 ¹
"	Kullen	7		6	15 ¹		11
Kattegatt	Hesselö	10		7	18 ¹		10 ¹
"	St. Middelgrund	6.5		9	14		10.5
"	L. Middelgrund	8		13	22		13.5
					1 extrapolated		

As could be expected, the difference in attenuation between the areas is very small in red light, as red absorption is mainly due to the water molecules. For blue light, on the other hand, the Öresund values could be expected to lie between the Baltic and the Kattegatt values, due to the normal amounts of yellow substance. This is true for cases like that shown in Fig. 63 A but not for situations similar to that in Fig. 63 B. The increased turbidity in the latter case is most probably caused by increased amounts of particles and dissolved decomposition products of organic matter.

Steemann Nielsen & Hansen (1961) stated that the 5 % level of downward irradiance for green light should be "equal to about 2 per cent of all photosynthetically active light". In Fig. 67 values for the 5 % level of downward irradiance in green light in 1958-59 by Steemann Nielsen & Hansen (*loc.cit.*) are compared with corresponding values in 1968-71 by the author. Both graphs show a seasonal variation with minima in spring and autumn but the light conditions have evidently become more unfavourable nowadays. Edler (1973) has demonstrated that the compensation depth for phytoplankton has decreased during the last decade.

Beam transmittance

Hermann (1967) gives the result of one measurement of beam transmittance west of Viken and G. Nyquist (personal communication) made one measurement west of Landskrona.

Only about ten series of measurements of beam transmittance have been performed by the author. Typical results of beam transmittance measurements are shown in Fig. 68 from Kullen and Fig. 69 A - B from Copenhagen. There are marked minima in transmittance values both for blue and red light, which coincide with changes in salinity. The results agree with Hermann's (*loc.cit.*) observations from Viken (Fig. 70). The phenomenon is commonly seen in the whole area and is also easily detected when SCUBA-diving, the halocline being seen as a 0.50 to 0.75 m thick layer of "milky" water. This is probably due to accumulation of organic compounds in the halocline.

With inflow of Kattegatt surface water into the Öresund there is no marked halocline and the beam transmittance shows no minimum (Fig. 71). On the other hand, Baltic surface water of 17-19 ‰ gives a high attenuation of light from 0 to 10 m in depth as far north as at Fladen (Fig. 72). When the whole water column at Fladen consists of Skagerrack water with a salinity of 30-34 ‰, higher beam transmittance values, however, are found from the surface to 35-40 m in depth (Fig. 73).

Quanta measurements

As photosynthesis is a quantum process, the number of quanta at different depths in the wavelengths relevant for the different algal groups must be known for studies of algal growth and estimation of biomass.

There are no previous quanta measurements from the Öresund area. In a few cases it has been possible to make quanta measurements. These have consisted of measurements of quanta/nm within the range from 400 to 700 nm and relative quanta measurements in the range from 350 to 700 nm. The results of these measurements are shown in Figs. 74 - 77. The difference between a very cloudy calm day in February, a slightly overcast day with moderate waves in the beginning of May and a calm cloudless day around the summer solstice, is apparent. The total number of quanta (400 nm - 700 nm) at 3 m in depth at noon in February is only about 2 % of the corresponding value in June. The results of the relative quanta measurements (Fig. 77) show that the 5 % level for the quanta within 350 - 700 nm is reached at about 10 - 14 m in depth and the 1 % level (extrapolated) at about 15 - 17 m in depth.

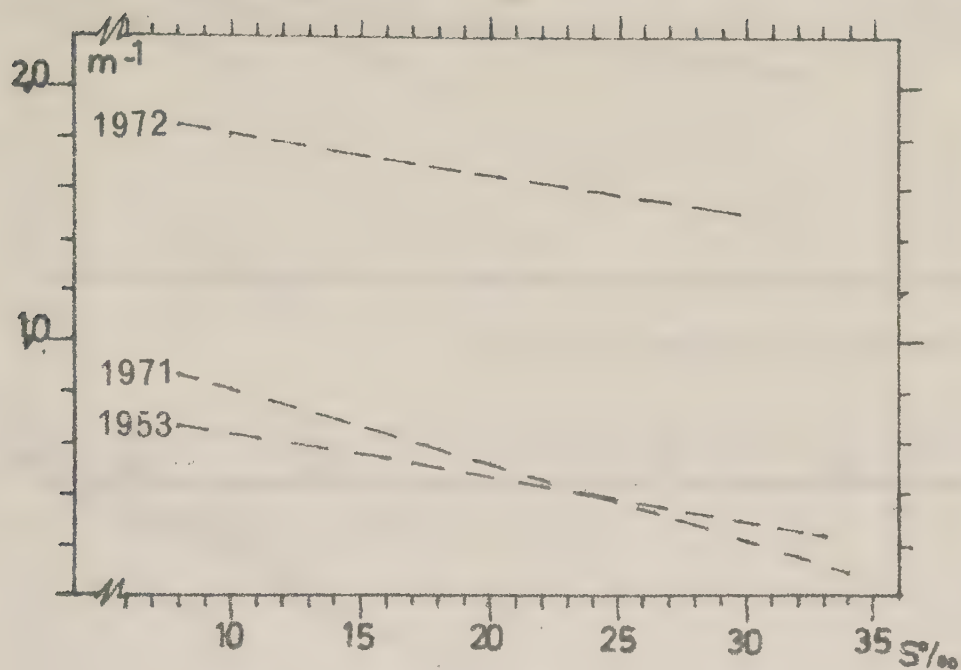


Fig. 62 A. The relation between the amount of yellow substance and salinity in the Öresund.
 1953 according to Jerlov (1953)
 1972 according to Bladh (1972)

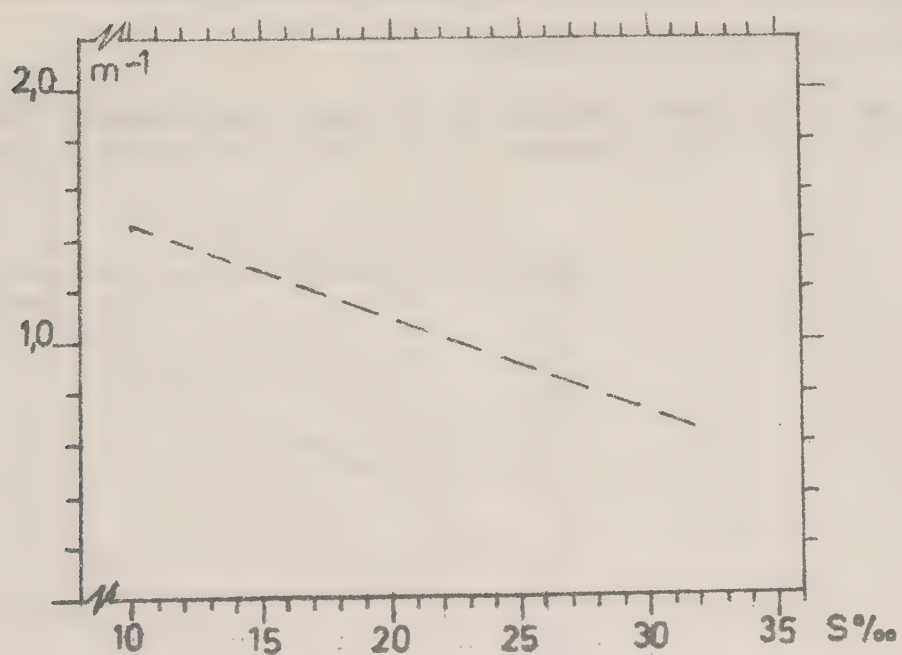


Fig. 62 B. The relation between the amount of yellow substance and salinity in the northern Öresund (Hornbæk-Viken) in 1972.

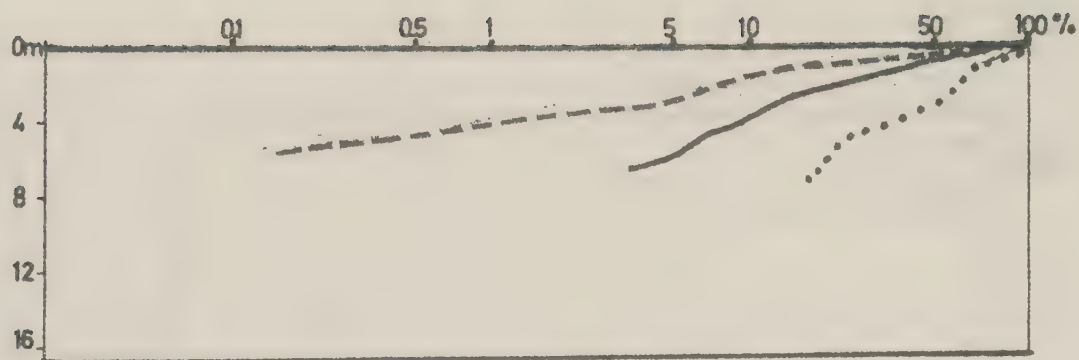


Fig. 63 A. Near Copenhagen 23/3 1968.

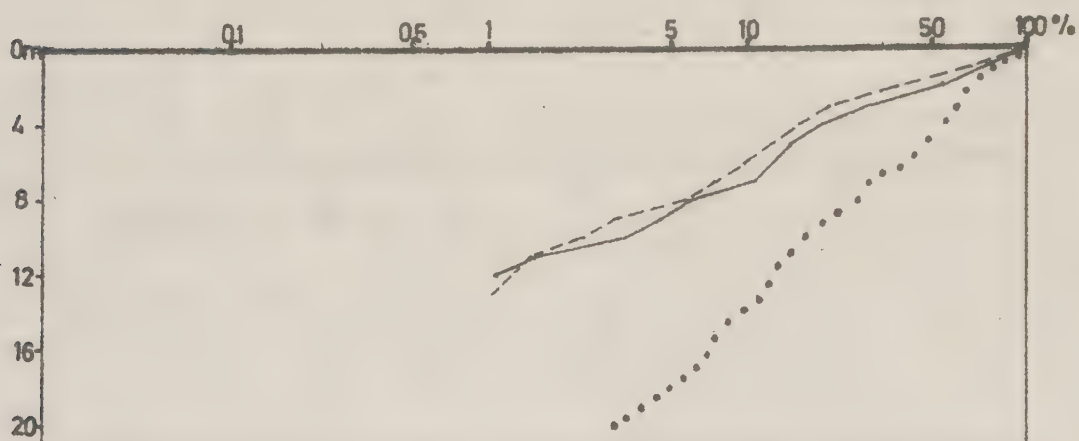


Fig. 63 B. Near Ven 14/4 1969.

Fig. 63 A - B. Depth profiles of the percentage downward irradiance in the Öresund. - - - blue green — red

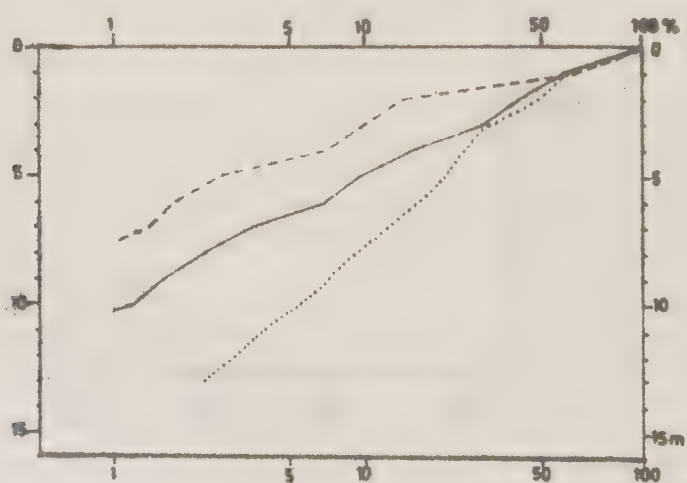


Fig. 64. Depth profile of the percentage downward irradiance in the Baltic, Hanö Bay 13/8 1972.
- - - blue green — red

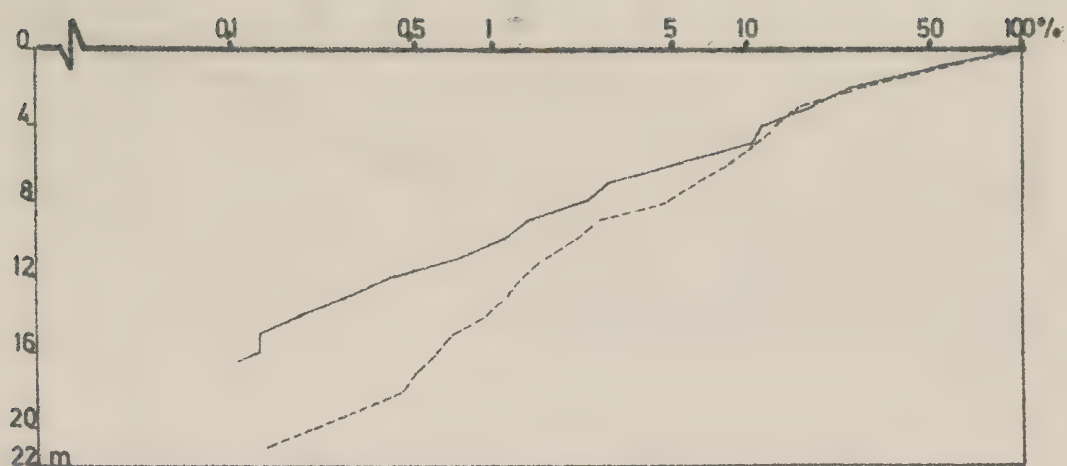


Fig. 65 A. At St. Middelgrund 23/9 1970.

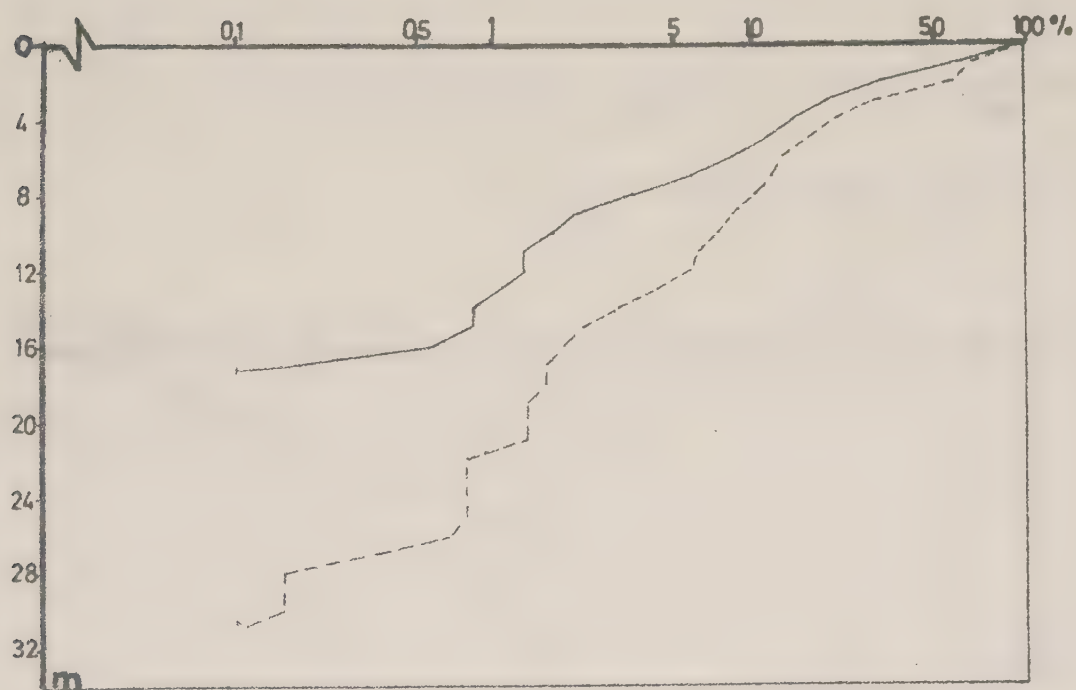


Fig. 65 B. At L. Middelgrund 24/9 1970.

Fig. 65 A - B. Depth profiles of the percentage downward irradiance in the Kattegatt.

----- blue light ————— red light

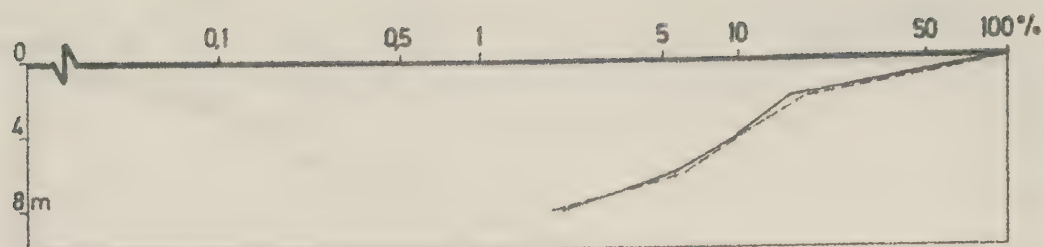


Fig. 66 A. Off Helsingborg 22/9 1970.

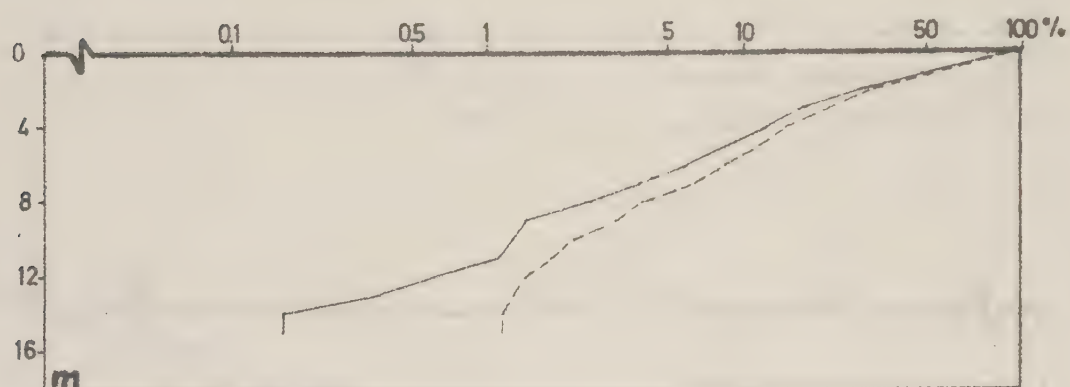


Fig. 66 B. West of Kullen 22/9 1970.

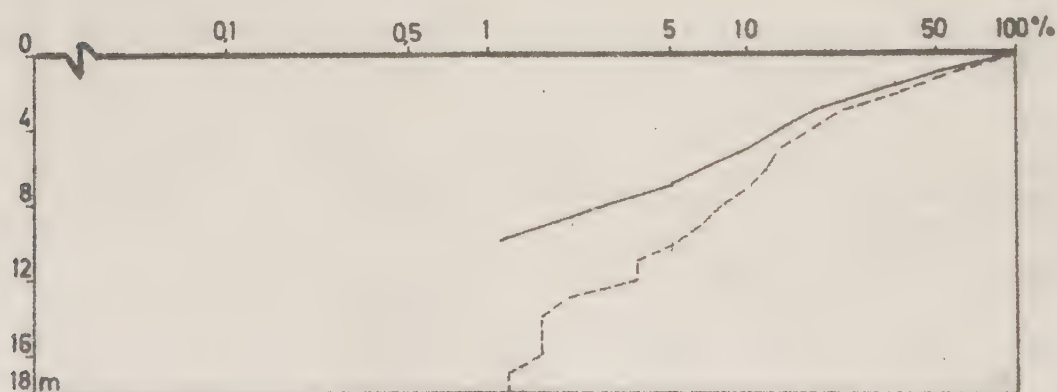


Fig. 66 C. Off Hesselö in southern Kattegatt 23/9 1970.

Fig. 66 A - C. Depth profiles of the percentage downward irradiance in the Öresund and southern Kattegatt.

----- blue light ————— red light

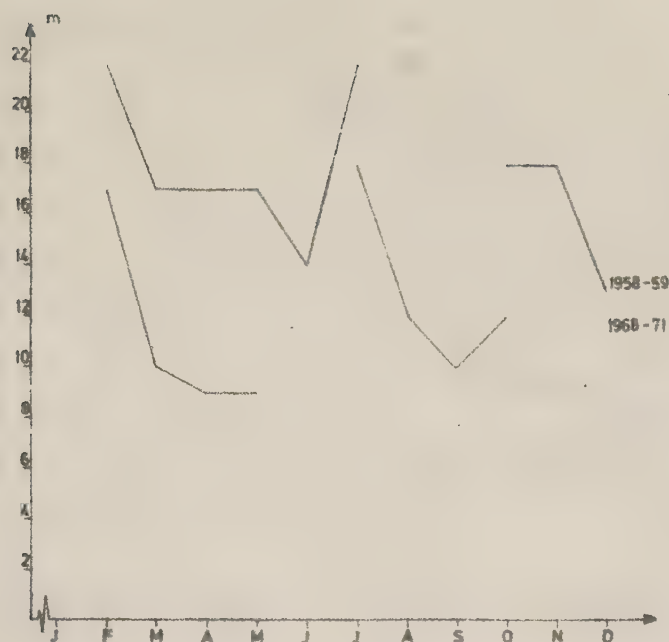


Fig. 67. Monthly variation in depth for the 5 % level of downward irradiance in green light.

1958-59 near Helsingör according to Steemann Nielsen & Hansen (1961)
 1968-71 mean values for the entire Öresund

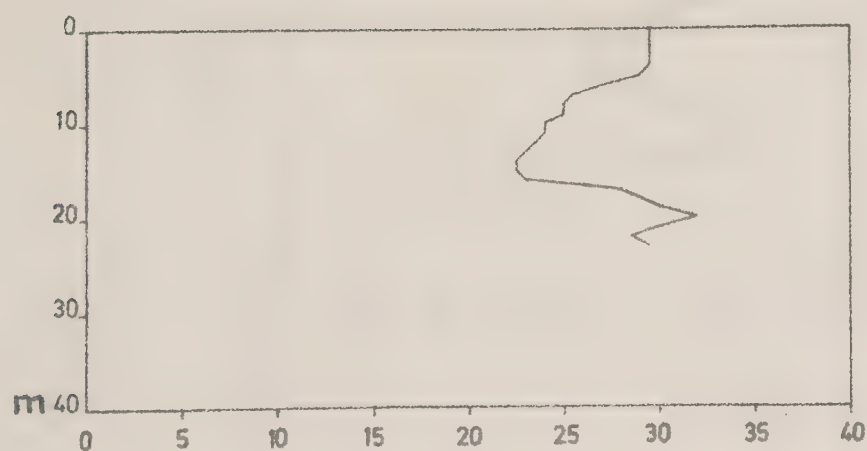


Fig. 68. The change in beam transmittance with depth in red light west of Kullen 22/9 1970. From v. Wachenfeldt (1971).

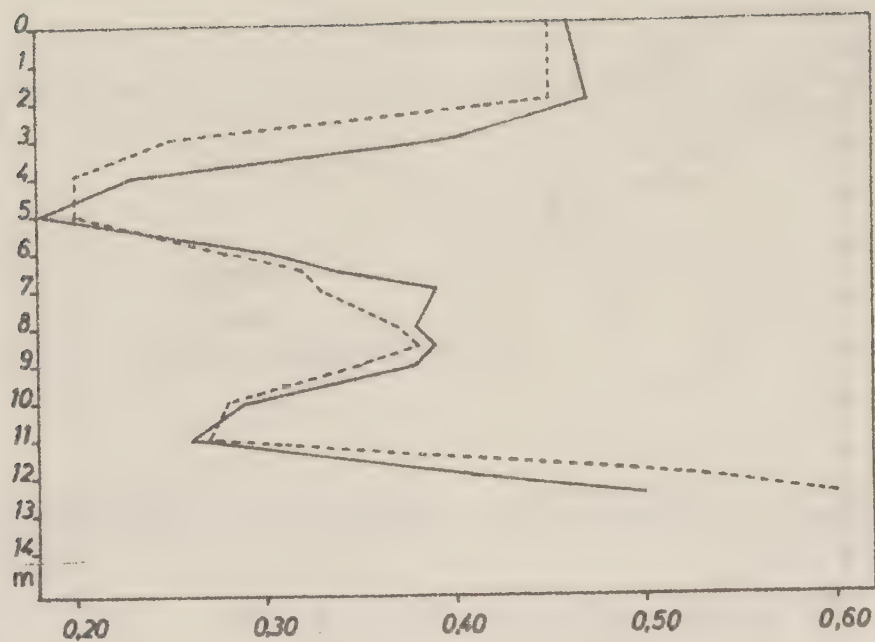


Fig. 69 A. Blue light.

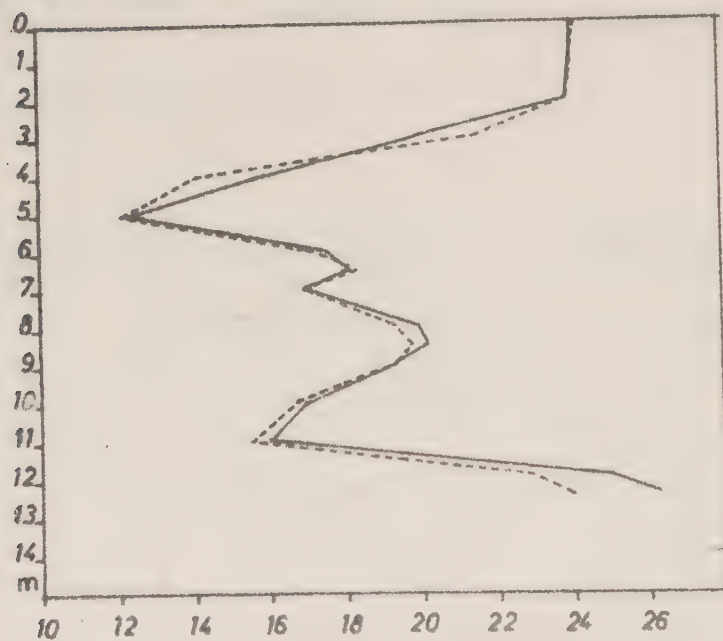


Fig. 69 B. Red light.

Fig. 69 A - B. Two measurements of the change in beam transmittance with depth outside Copenhagen 27/3 1968. From v. Wachenfeldt (1971).

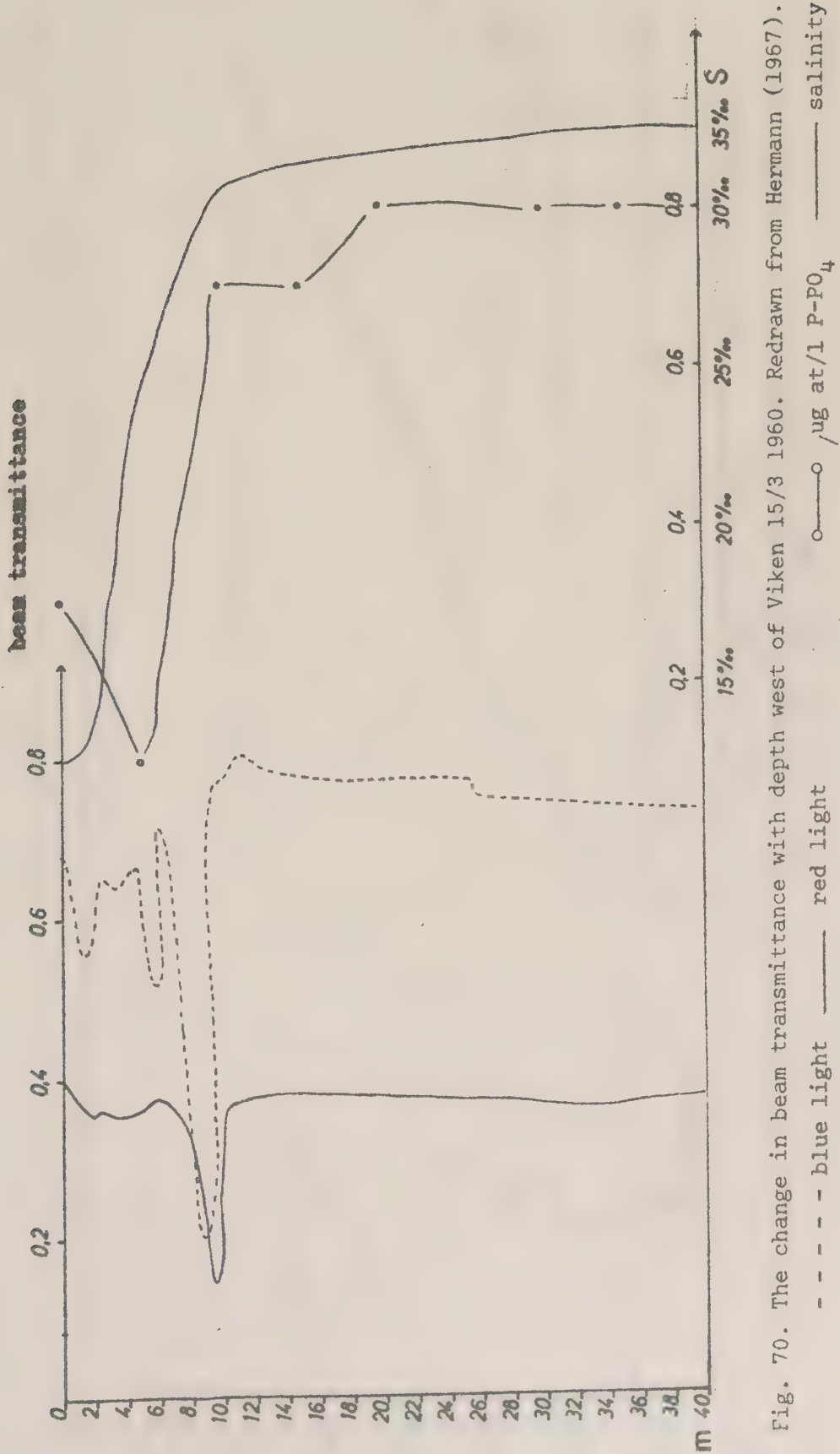


Fig. 70. The change in beam transmittance with depth west of Viken 15/3 1960. Redrawn from Hermann (1967).

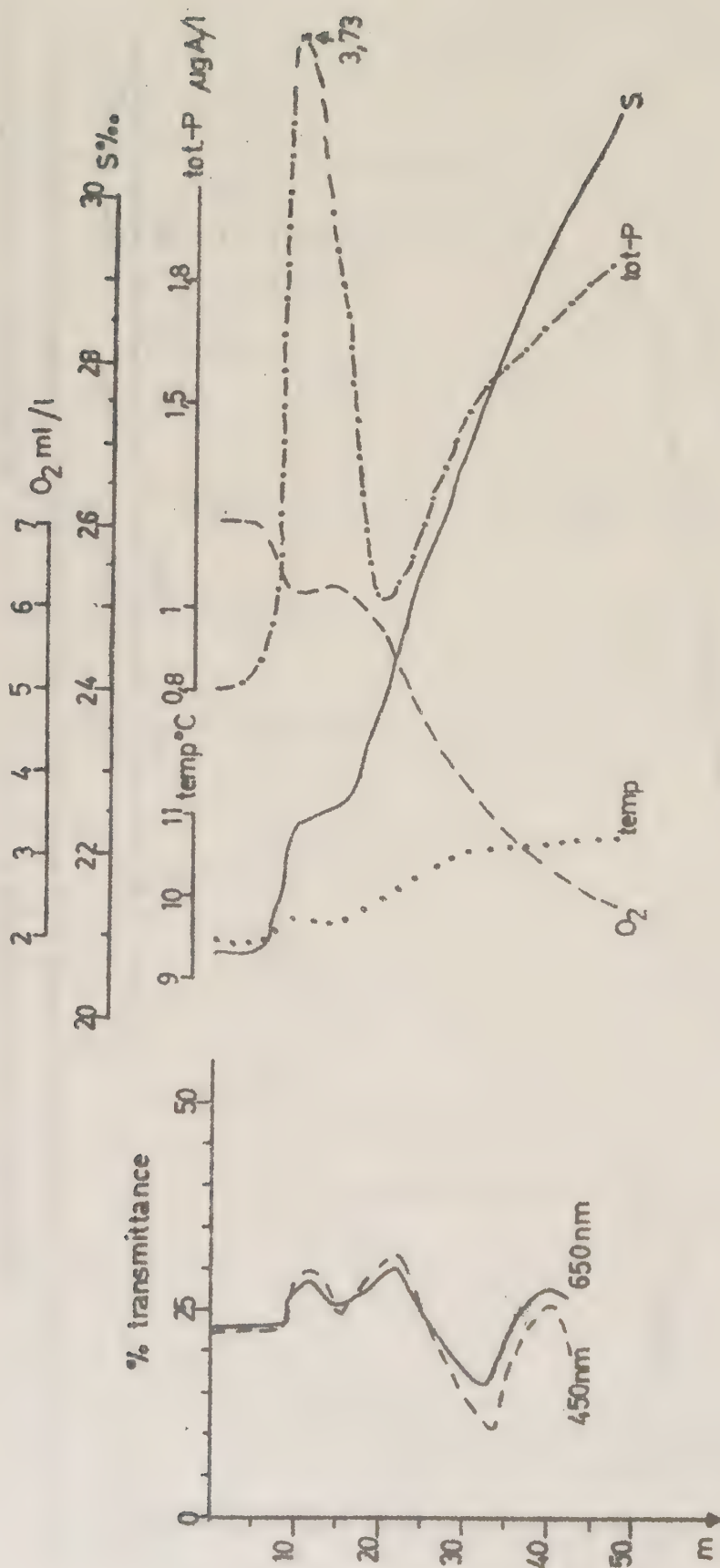


Fig. 71. Beam transmittance measurements for blue and red light at the Landskrona Deep 26/10 1972.
 From G. Nyquist (unpubl.).

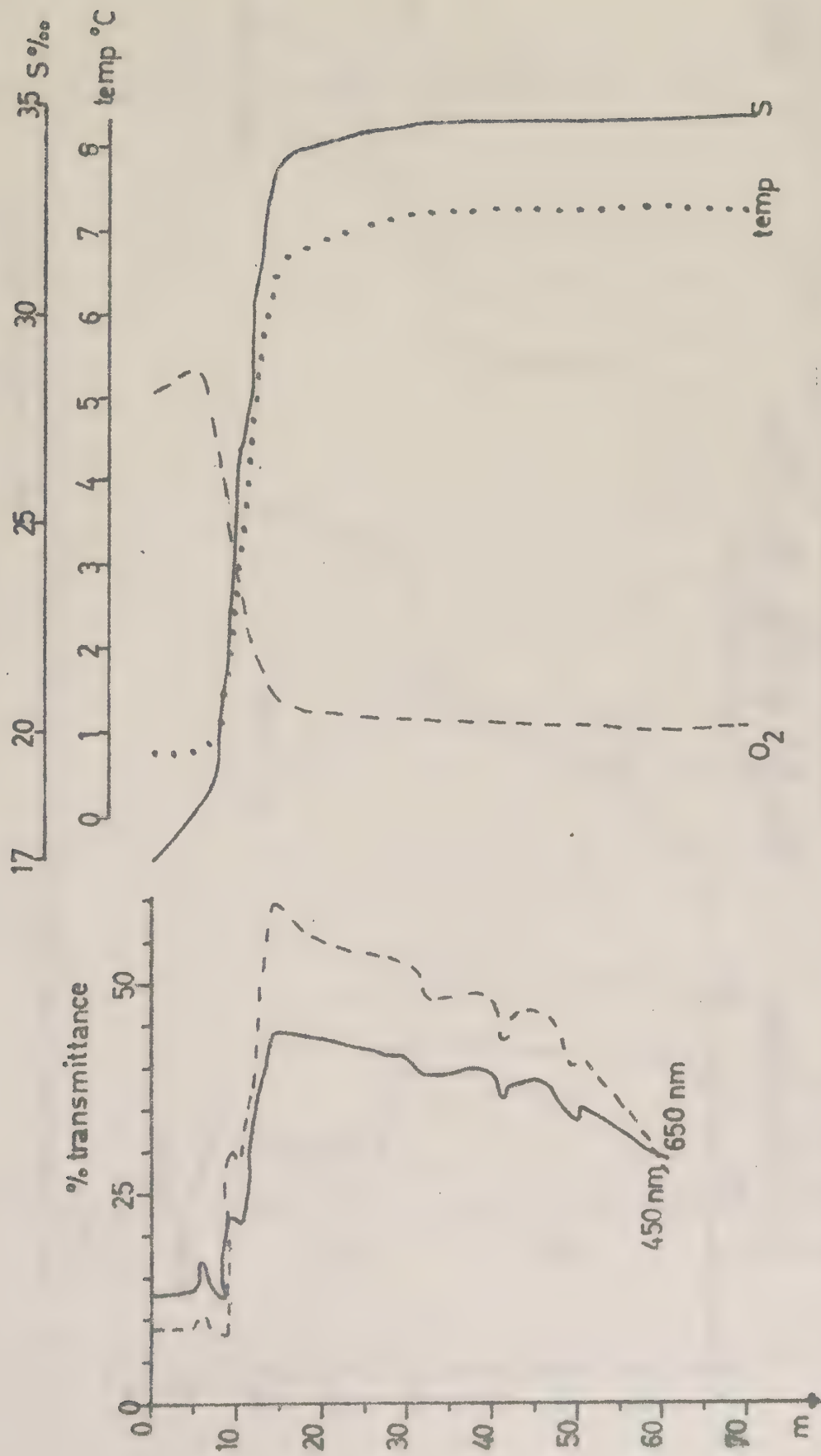


Fig. 72. Beam transmittance measurements for blue and red light at Fladen (Kattegatt) 28/2 1972.
From G. Nyquist (unpubl.).

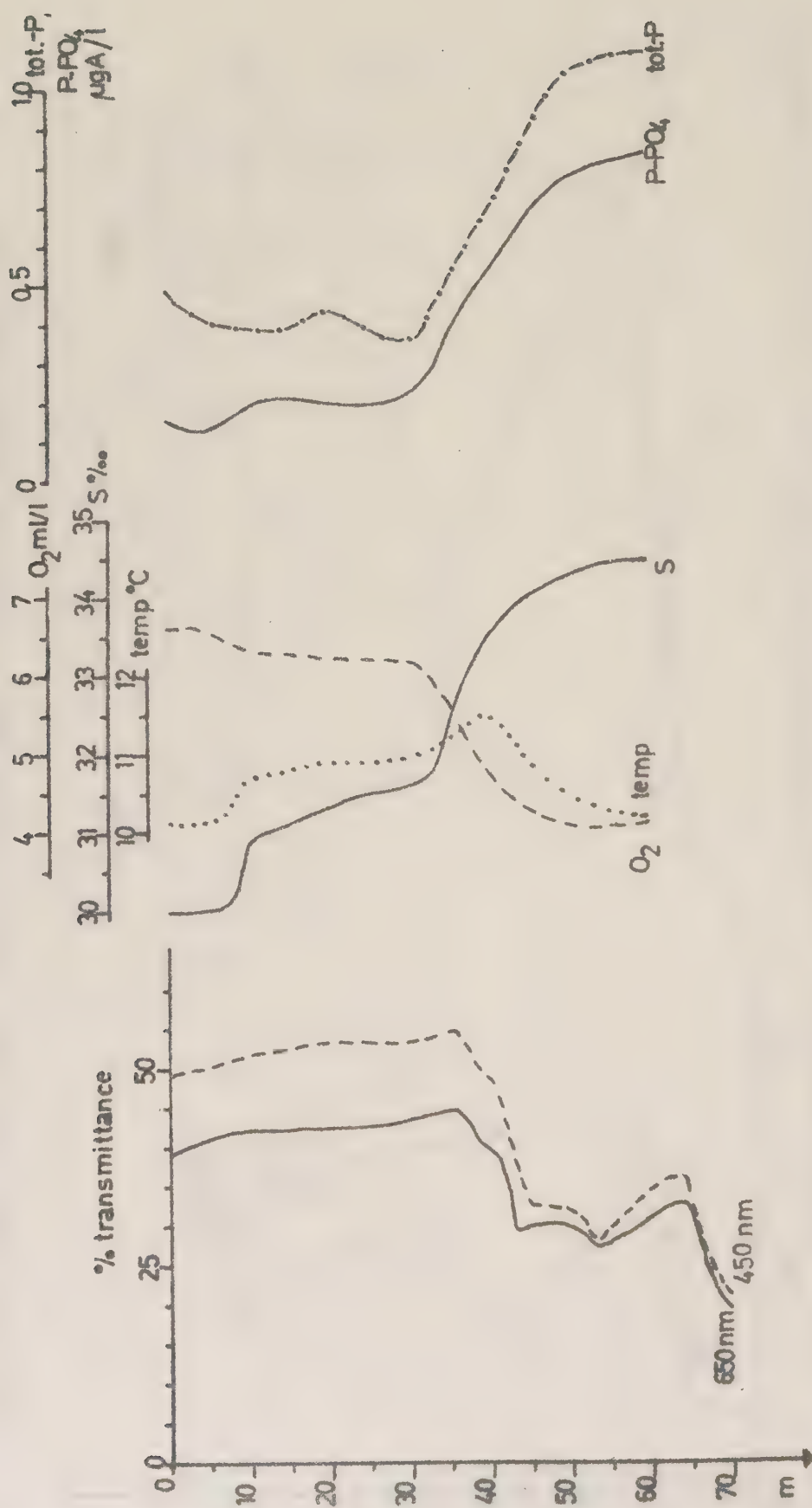


Fig. 73. Beam transmittance measurements for blue and red light at Fladen (Kattegatt) 25/10 1972.
From G. Nyquist (unpubl.).

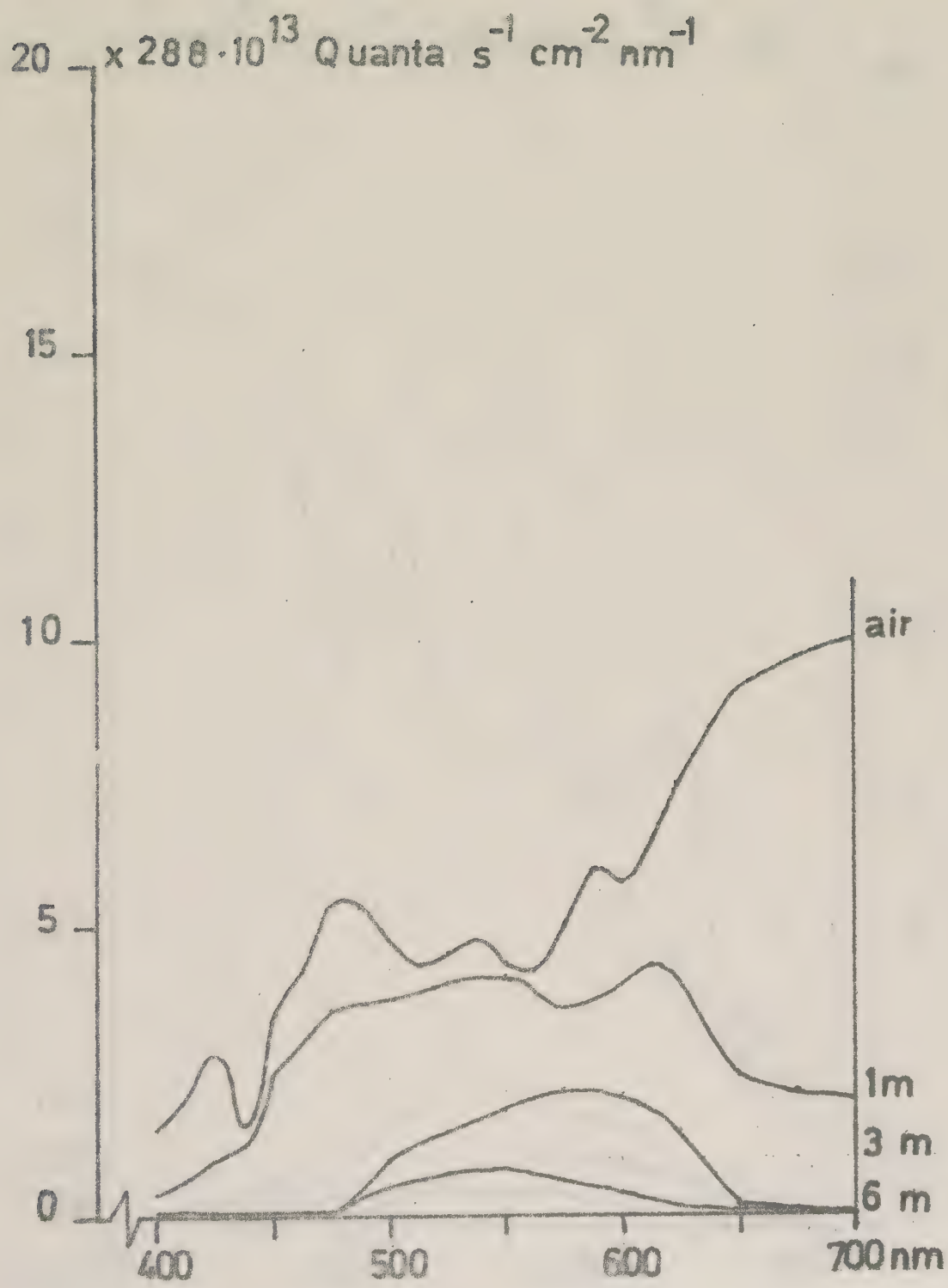


Fig. 74. Quanta measurements within the range 400-700 nm in air and at 1, 3 and 6 m in depth west of Landskrona 20/2 1972.

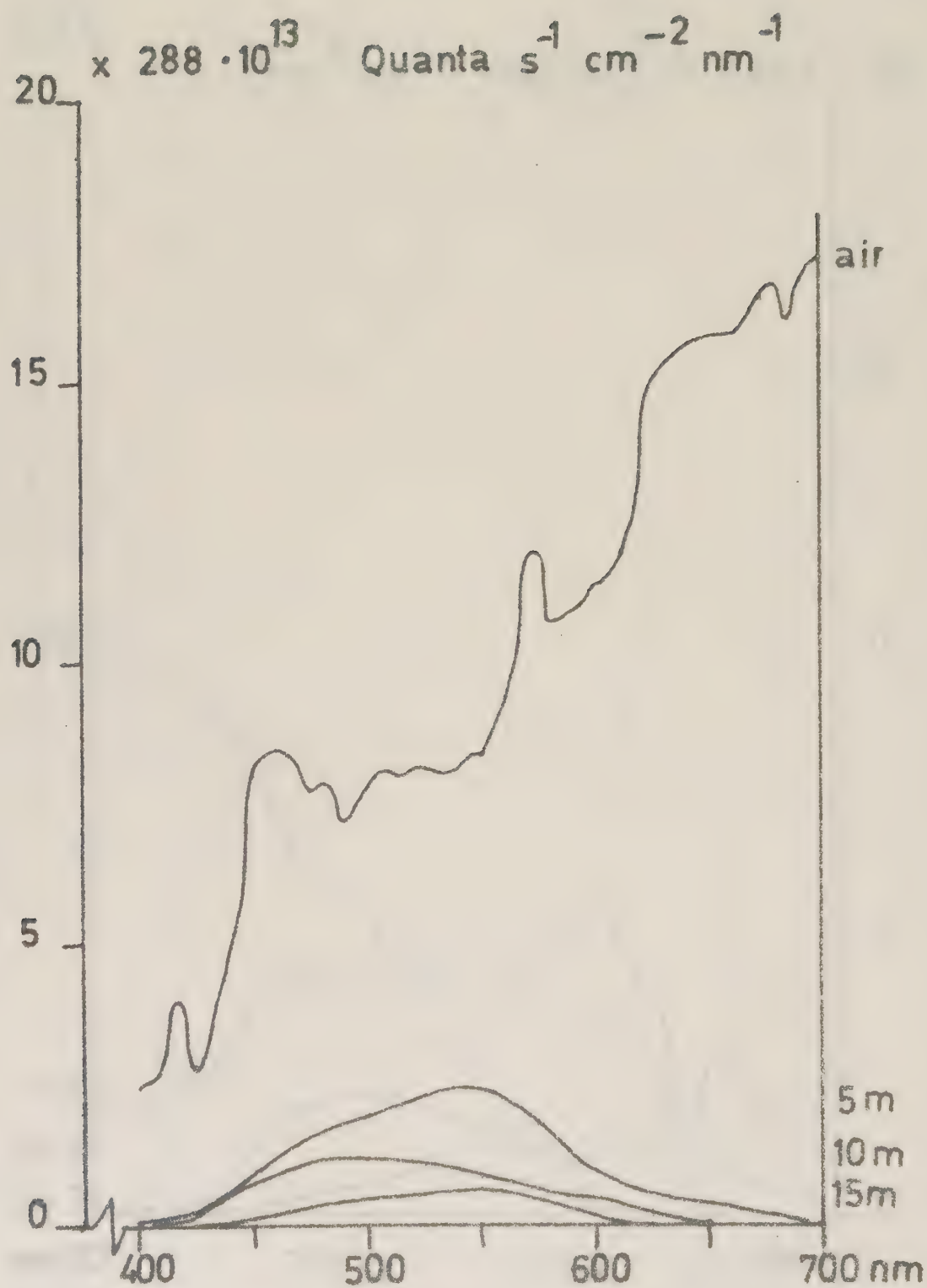


Fig. 75. Quanta measurements within the range 400-700 nm in air and at 5, 10 and 15 m in depth at station 1 on the Hornbaek-Viken transect 16/5 1972.

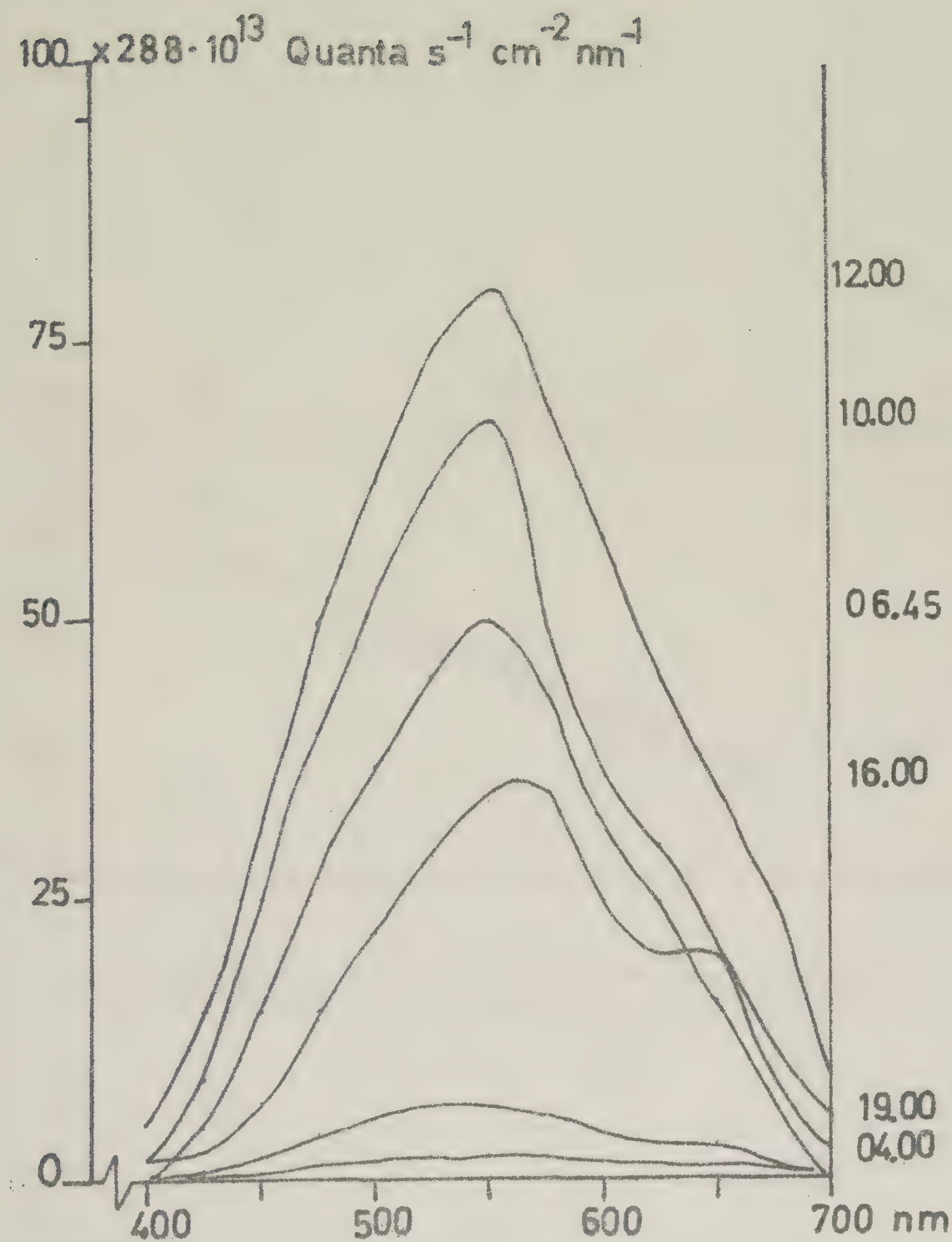


Fig. 76. Quanta measurements within the range 400-700 nm at 3 m in depth at Lerhamn at different times of the day, 27/6 1972.

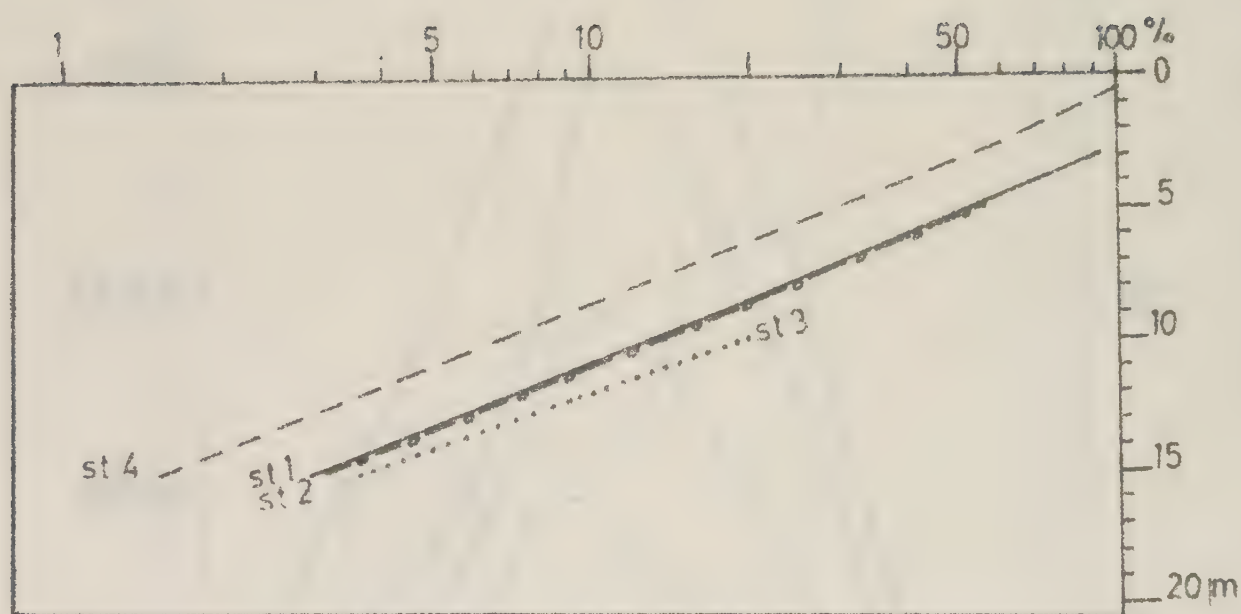


Fig. 77. Relative quanta measurements, the range 350-700 nm integrated, at station 1 - 4 on the Hornbaek-Viken transect 3/5 1972.

COMPOSITION OF THE ALGAL FLORA

In the following section the composition of the algal flora, the distribution, characters, reproduction and autecology of the species will be described.

The aim of this investigation is not to make a systematic revision but to attempt to get a picture of the influence of some of the environmental factors on the marine vegetation in a comparatively small area. For practical reasons, therefore, valid taxonomical units and current nomenclature are used, mainly Dixon & Parke (1968).

As far as possible, the previous known distribution of the different species in the Öresund area and in adjacent Swedish and Danish waters is given, in order to put the algal flora of the Öresund in a wider context. This information is mainly derived from Kylin (1907, 1944, 1947, 1949), Levring (1935, 1940), Waern (1952), Rosenvinge (1909, 1917, 1923-24, 1931, 1935), Rosenvinge & Lund (1935, 1941, 1943, 1947) and Lund (1950). For the distribution in Danish waters, the districts proposed by Rosenvinge (1909) have been used. When no references are given for the distribution in Danish waters, the information is taken from Christensen & Thomsen (1974). Furthermore, the algal collections in the herbaria in Lund, Copenhagen and Gothenburg have been studied.

To indicate the relative frequency of the different species the following terms have been used:

Common	Found at all suitable localities in high numbers
Abundant	Found at all suitable localities, in varying numbers
Frequent	Mostly found at suitable localities, though in low numbers
Sparse	Not found at all suitable localities, always in low numbers
Rare	Found about 5 - 25 times

The division of the shore area in different regions has been dealt with by many authors and a rich "flora" of terms has been established by, e.g. Kylin ("physiological high water line") (1918), Sjöstedt ("litos line") (1928 a), Levring (1937), Du Rietz (1947), Steemann Nielsen (1951) and Lewis (1964). Since definitions differ from author to author, the terms have often been confused. The author has chosen to follow Levring (1937), as his system is clear and easy to follow and can be adopted in field work:

Supralittoral zone	From the lower border of the lichen <i>Parmelia saxatilis</i> to the 0-line
Littoral zone	From the 0-line to the upper limit of <i>Fucus serratus</i>
The 0-line	The border between the lower limit of <i>Verrucaria maura</i> and the upper limit of <i>Balanus</i> sp. (<i>B. balanoides</i> , <i>B. improvisus</i>)
Sublittoral zone	From the upper limit of <i>Fucus serratus</i> down to the lower border of the vegetation

To get an idea of how different species react to changes in salinity, the author has tried to make a classification of the species in a so-called "Halobien system". Many attempts have been made to classify brackish waters by, among others Redeke (1922, 1929, 1933), Kolbe (1927), Ekman (1953), Hustedt (1957) and the Symposium on the classification of brackish waters in Venice (1958). Both the system of Hustedt and the "Venice system" are useful. The author, however,

has chosen to use the system of Hustedt modified by Simonsen (1962) instead of the "Venice system", because the latter becomes too complicated when a species area covers several intervals in the scale. The system of Hustedt was originally designed for diatoms but agrees quite well with the biological borderlines in the present investigation. To precise the group "euryhaline" in the Hustedt system, Simonsen (loc.cit.) suggested the following groups for tolerance to changes in salinity (hypotonic tolerance) for different species:

Polyhalobe oligoeuryhaline species	35 to about	30 ‰
Polyhalobe meioeuryhaline species	35 to about	17 - 20 ‰
Polyhalobe mesoeuryhaline species	35 to about	8 - 10 ‰
Polyhalobe pleioeuryhaline species	35 to about	3 - 5 ‰

This corresponds quite well to the classification given by Hermann (1967) of water in the Öresund according to salinity:

Kattegatt bottom water	30 - 34 ‰
Kattegatt surface water	18 - 24 ‰
Baltic surface water	8 - 10 ‰

RHODOPHYTA

RHODOPHYCEAE

BANGIOPHYCIDAE

PORPHYRIDALESPorphyridiaceaePorphyridium marinum Kylin

Distribution Sweden: Bohuslän: Kristineberg, Kylin (1944).

Denmark: North Kattegatt.

This species was established by Kylin (1937a) and has since then not been found in Sweden until this investigation. Pringsheim & Pringsheim (1956) and Rieth (1961) have shown that the species probably is conspecific with the terrestrial *Porphyridium cruentum* = *Porphyridium purpureum* (Bory) Drew et Ross. As long as this has not been proved beyond doubt the author will continue to use Kylin's name.

Porphyridium marinum has been found twice in the Öresund. One find was made in culture studies where unfiltered water from a depth of 25 m in Hornbaek Bay was used. On the walls of the culture vessel *Porphyridium marinum* appeared as 1 - 3 mm big cushions. The other find was made on glass fragments dredged from a depth of 20 m near Hallands Väderö. In this case the species covered the glass in thin dots about 1 cm in diameter. In both cases the cells were 7 - 10 μ in diameter and fully in agreement with Kylin's description.

Rieth (loc.cit.) suggested that *Porphyridium marinum* is a planctonic red alga. In view of the find from Hallands Väderö, this seems not to be the case. The present author is of the opinion that the species may grow mainly on soft bottoms like the terrestrial species and this could explain why *Porphyridium marinum* is known only from a few localities in Europe and America.

Localities: Hallands Väderö, Hornbaek Bay.

Polyhalobe meioeuryhaline.

GONIOTRICHALESGoniotrichaceaeAsterocytis ramosa (Thwaites in Harv.) Gobi ex Schm.

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935); Blekinge, Levring (1940); Öregrund, Waern (1952).

Denmark: South Kattegatt, Samsö, The Belts, Smålandshavet, Bornholm.

The delimitations between *Asterocytis ornata* (Ag.) Hamel, *Asterocytis ramosa* (Thwaites in Harv.) Gobi ex Schm., *Asterocytis smaragdina* (Reinsch) Forti and *Asterocytis wolleana* (Hansgirg) Lagerh. are not clear. This complex has been discussed by Waern (loc.cit.), among others.

Asterocytis ramosa is frequently found in the Öresund, mostly from 0 - 5 m in depth but also more seldom down to 20 m in depth. It grows epiphytically, mainly on *Ceramium* sp. and *Polysiphonia* sp. Sjöstedt (1927), Levring (1940) and Waern

(loc.cit.) believed that *Asterocytis. ramosa* is favoured by polluted water. No such tendency has been found in the present author's material.

The filaments vary from 1 - 1.5 mm in length and 10 - 21 μ in diameter. The species is found throughout the year but mostly during summer. No spore formation has been noticed.

Localities: Hallands Väderö, Kullen, Lerhamn, Hornbaek Bay, Grälleggrund, Limhamn, Klagshamn, Bredgrund.

Polyhalobe pleioeuryhaline.

Goniotrichum alsidii (Zanard.) Howe

(*Goniotrichum elegans* (Chauv.) Le Jol.)

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935).

Denmark: Kattegatt, Samsö, Little Belt.

This little red alga is regularly, though not commonly, found in the north and central part of the Öresund from 5 - 25 m in depth. It grows epiphytically, mostly on *Ceramium* sp., *Polysiphonia* sp., *Spermothamnion repens* and *Trailliella intricata*.

The length of the filaments varies from 1 - 3 mm and the breadth from 12 - 16 μ . The species is found all the year round and the majority of specimens are sterile. Monosporangia have been found a few times from June to September in the north part of the area.

Localities: Off Hallands Väderö, off Kullen, Vattenmöllan, Hornbaek Bay, Grälleggrund, Ven, Staffansbank, Barsebäck.

Polyhalobe meioeuryhaline.

Bangiales

Erythropeltidaceae

Erythrocladia irregularis Rosenv.

Distribution Sweden: Bohuslän, Kylin (1944); Kullen, Levring (1935).

Denmark: North Kattegatt.

Pankow (1971) considers without any explanation *Erythrocladia irregularis* Rosenv. and *Erythrocladia polystromatica* Dang. to be conspecific. This is probably incorrect, as *Erythrocladia irregularis* is monostromatic and *Erythrocladia polystromatica* polystromatic. The author has noticed *Erythrocladia polystromatica* in Blekinge and found it quite distinct from *Erythrocladia irregularis*.

This tiny red epiphyte which can be very difficult to find, was recorded only once by Levring (loc.cit.). It is, however, frequently found in the north part of the Öresund area from 5 - 20 m in depth on *Chondrus crispus*, *Polysiphonia* sp. and *Rhodomela confervoides*.

The specimens which are regularly branched are about 30 - 40 μ in diameter. The cells are 3 - 4 x 6 - 9 μ . Jaasund (1965) reports from north Norway a diameter of about 150 μ . As a rule it is not difficult to separate *Erythrocladia irregularis* from *Erythrocladia subintegra*. But on a few occasions, when the specimens have been more branched than usual, the delimitation can be uncertain. *Erythrocladia* species could be mistaken for *Acrochaetium macula*, but they differ from this by not having hairs.

The species is found throughout the year. Monosporangia are seldom noticed. Most specimens obtained have been sterile.

Localities: Off Hallands Väderö, Kullen, Vattenmöllan, Hornbaek Bay, Grälleggrund.

Polyhalobe meioeuryhaline.

Erythrocladia subintegra Rosenv.

Distribution Sweden: Bohuslän, Kristineberg, Kylin (1944); Kullen, Levring (1935).

Denmark: North and East Kattegatt.

This species is more frequent than *Erythrocladia irregularis* though Levring (loc.cit.) only found a few specimens at Kullen. Both species often occur together. *Erythrocladia subintegra* is found in the north part of the Öresund and at a few localities in the central part from 3 - 25 m in depth. It is mostly found on *Ceramium* sp., *Polysiphonia* sp. and *Rhodomela confervoides*, always on the older parts of the hosts.

The species grows as suborbicular discs with as a rule regularly radiating filaments, 30 - 50 μ in diameter. The cells are 3 - 4 x 7 - 9 μ . Specimens are found during the whole year. Monosporangia, 4 - 5 μ in diameter, are frequently recorded from June to September (- October).

Localities: Hovs Hallar, off Hallands Väderö, Kullen, Vattenmöllan, Ellekilde hage, Hornbaek Bay, Hälsingborg, Ven, Staffansbank.

Polyhalobe meioeuryhaline.

Erythrotrichia carnea (Dillw.) J. Ag.

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935).

Denmark: Kattegatt, Samsö, The Belts, Öresund, W.Baltic.

Erythrotrichia carnea is found sparsely in the north part of the area and at a few localities in the central part. It grows from (1) - 5 - 25 m in depth on i.a. *Ascophyllum nodosum*, *Ceramium* sp. *Odonthalia dentata*, *Phycodrys rubens* and *Polysiphonia* sp. Kylin (loc.cit.) suggests that *Erythrotrichia carnea* is favoured by polluted water, but this is not the case in the Öresund area.

The filaments rarely reach more than 9 - 10 mm in length and 10 - 15 μ in breadth. Very few threads of 10 - 15 mm in length have been recorded. The species is found throughout the year but most frequently from June to October. Only a few specimens with monosporangia have been noticed.

Localities: Off Hallands Väderö, Kullen, Vattenmöllan, Lerhamn, Höganäs, Ellekilde hage, Hornbaek Bay, Grälleggrund, Ven, Barsebäck.

Polyhalobe meioeuryhaline.

Porphyropsis coccinea (J. Ag. ex Aresch.) Rosenv.

Distribution Sweden: Bohuslän, Brandskären, Grisbodarna, Areschoug (1850); Kristineberg, Kylin (1944); Falkenberg, Levring (1933); Hallands Väderö, Suneson (1941); Kullen, Levring (1935).

Denmark: Kattegatt.

Levring (loc.cit.) found the species once: "einige wenige Exemplare". The author, however, has found *Porphyropsis coccinea* frequently in the north part of the

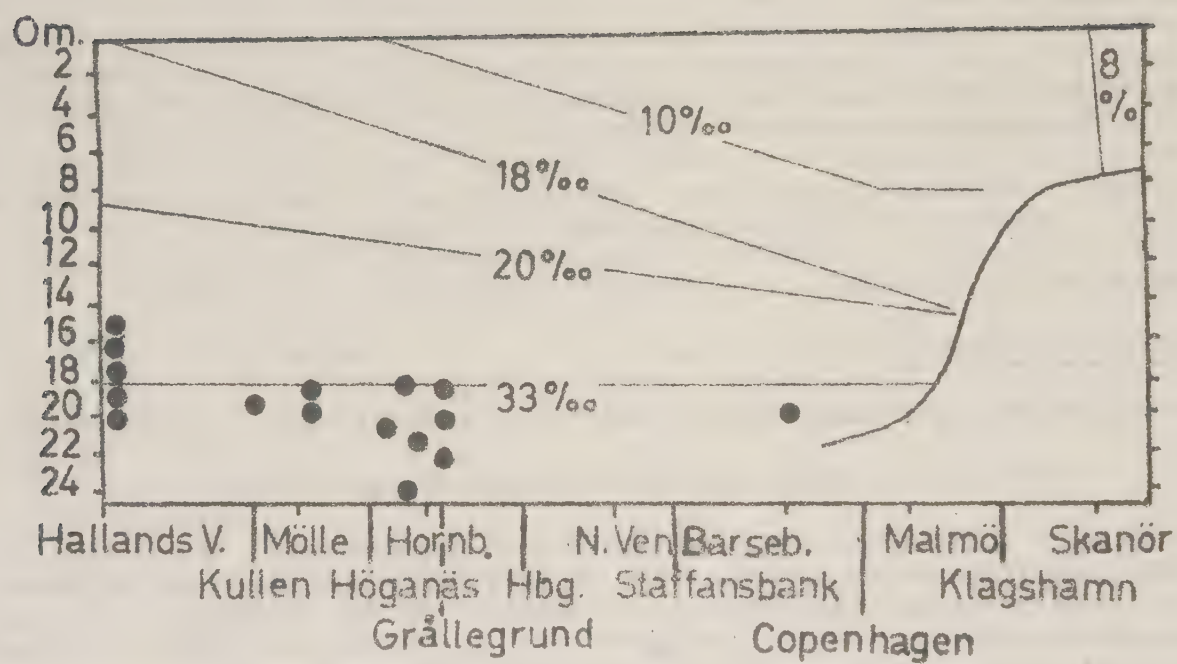


Fig. 78. The distribution of *Porphyropsis coccinea* in relation to depth and salinity.

Öresund and at Barsebäck, from 15 - 25 m in depth on *Chaetomorpha melagonium* and *Desmarestia aculeata*.

The diameter of the one-layered thalli varies from 2 - 4 mm, though some single specimens have been up to 6 mm. Specimens are found throughout the year. Juvenile cushion-formed stages have been met with in February and the largest specimens in September and October. All examined specimens have been sterile.

Localities: Off Hallands Väderö, Kullen, Vattenmöllan, Hornbæk Bay, Grälleggrund, Barsebäck. (Fig. 78)

Polyhalobe meioeuryhaline.

Bangiaceae

Bangia fuscopurpurea (Dillw.) Lyngb.

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935); Blekinge, Levring (1940); Stockholm, Öregrund, Waern (1952); Haparanda, Krok (1869).

Denmark: Kattegatt, The Belts, Öresund.

Several taxa within *Bangia* have been described: *Bangia atropurpurea* (Koth) C.Ag. (fresh water species), *Bangia crispa* Lyngb., *Bangia fuscopurpurea* (Dillw.) Lyngb. and *Bangia pumila* Aresch. Levring (1940) considered them to be only modifications of *Bangia fuscopurpurea* (Dillw.) Lyngb.

The distribution of *Bangia fuscopurpurea* is peculiar. Kylin (loc.cit.) states: "an der bohuslänschen Küste gemein, an der halländischen Küste dagegen ziemlich spärlich". Rosenvinge (1935) mentions four finds from the Öresund. Levring (1940) found the species in Blekinge: "bei Karlshamn massenhaft vor und war assoziationsbildend" and there are finds along the Baltic coast to Haparanda: Waern (loc.cit.) and Krok (loc.cit.). Finds have also been made from inland waters, e.g. by Steenloff (1934). The discontinuous distribution with one population along the west coast and another in the Baltic suggests that either the species is sensitive to fluctuating salinity or we are dealing with separate taxa. This has to be resolved by culture studies.

Bangia fuscopurpurea is very common in the north part of the Öresund, sparse in the central and south part down to Limhamn - Dragör and not found in the southernmost part. Judging from Rosenvinge (loc.cit.) and Levring (1935) it is possible that the species in the whole area has become more abundant during the last decade probably due to the pollution situation. *Bangia fuscopurpurea* forms a belt at semi-exposed to exposed localities in the supralittoral and littoral zone from about 1.5 m above to just below the 0-line.

The first sign of *Bangia* filaments, 1 - 2 cm long, is as a rule found at the beginning of December. The main growth takes place in February to March when the filaments reach a length of 4 - 6 cm. At some very polluted localities near Helsingborg and Helsingör, however, *Bangia fuscopurpurea* has been observed in full length and in dense belts already in the middle of October. The species often grows together with *Porphyra linearis* and *Ulothrix-Urospora* sp. At many localities *Bangia fuscopurpurea* is more or less overgrown by *Porphyra linearis* which seems to retard the *Bangia* growth. When *Porphyra linearis* decays in March, *Bangia fuscopurpurea* is exposed and the growth is improved. At other localities, however, *Bangia fuscopurpurea* in March and April becomes overgrown by *Ulothrix-Urospora* and does not survive. Most of the *Bangia* belt disappears normally in April, but small patches can survive until at least the middle of June. No traces of *Bangia fuscopurpurea* have been noticed from July to October. In some cold years the main part of the *Bangia* belt has been killed by frost.

The formation of monospores takes place from the end of February to March (April). Female plants with small trichogynes have frequently been found in March and April.

Localities: Belt formations : Hovs Hallar, Torekov, Hallands Väderö, Kullen, Lerhamn, Gilleleje, Hornbaek, Helsingör, Helsingborg, Ven.
Small patches : Barsebäck, Tuborg, Copenhagen, Dragör, Limhamn.

Polyhalobe pleioeuryhaline.

Porphyra leucosticta Thur. in Le Jol.

Distribution Sweden: Bohuslän, Koster, Kristineberg, Kylin (1944).

Denmark: N. and S. Kattegatt, Öresund.

Porphyra leucosticta is found sparsely in the north part of Bohuslän during summer (May - September) according to Kylin (loc.cit.) and own observations. In the Öresund area Rosenvinge (1935) found the species near Copenhagen, fully developed in May. This local population has survived here since then, but has not been able to expand its distribution area. Kristiansen (1972) has investigated a jetty in Tuborg harbour in 1957-59 and found the species in all months of the year except from July to September.

The author has found some single specimens of *Porphyra leucosticta* north of Tuborg in the littoral zone during spring (April - May). They were 4 - 8 cm long and fertile.

Locality: Tuborg. (Fig. 79)

Polyhalobe mesoeuryhaline.

Porphyra linearis Grev.

Distribution Sweden: Bohuslän, Kristineberg, Kylin (1944); Kullen, Sjöstedt (1928 a) and Levring (1935).

Denmark: Kattegatt.

Porphyra linearis was considered as a form of *Porphyra umbilicalis* by Rosenvinge (1909) and Rees (1940). Both morphology and ecology are, however, quite different from other *Porphyra* species. Kornmann (1961 a) has also shown that the conchocelis stage is different.

Porphyra linearis is very common in the north part of the area down to Mölle and forms a dense belt, 0.5 - 1.5 m wide. In some years it is also noticed at Helsingör. At Ven one can also find small belts on the north side probably due to higher salinity. The *Porphyra linearis* belt is found at exposed and very exposed localities in the supralittoral zone, from about 0.2 m above the 0-line up to 1.5 - (3 - 6) m depending on the degree of exposure. Thus, *Porphyra linearis* is not submersed, at least not for long periods. The lower border coincides with the upper limit of *Petalonia zosterifolia*. Between Mölle - Gilleleje and Helsingborg - Helsingör one can find single reduced specimens of 2 - 3 x 15 - 30 mm with quite different ecological demands. It grows in very sheltered positions on the back side of larger stones.

The thalli are normally 10 - 12 cm in length and 5 - 8 mm in breadth. Specimens which are 15 - 25 cm long and 10 - 12 mm broad have been found occasionally. They were most common in 1967 due to the high salinity caused by north-west gales during October and November. The colour of the species is dark red-violet. Old decaying specimens can be light red.

Porphyra linearis is a typical winter species and appears constantly in the middle of October, probably a short-day and cold-water phenomenon. After 14 - 21 days full size is reached. The *Porphyra linearis* belt, however, does not reach its fully breadth until December. This widening of the *Porphyra linearis* belt occurs at the same time as the high-water and stormy period in December. The "October specimens" are probably derived from conchospores of the conchocelis face and the

"December specimens" from carpospores or some other kinds of spores which develop directly to new *Porphyra* blades. That this latter is possible has been shown by Tseng and Chang (1955) and Kornmann (1961 a) in *Porphyra leucosticta*. Normally *Porphyra linearis* disappears at the end of March and in the middle of April no sign of the species is visible. Fertile specimens are found from November to December (-March).

Porphyra linearis can apparently survive desiccation during more than 10 days and withstand short periods of temperatures down to -10°C . Lower temperatures or coating by ice for longer periods such as 30 days or more (e.g. in spring 1969) is fatal to the species. It also seems to be very sensitive to oil spill, even at low concentrations.

Localities: Belt formations, exposed localities: Hovs Hallar, Torekov, Hallands Väderö, Kullen, Mölle, Gilleleje, Helsingör (occasionally), Ven.
Single specimens, sheltered positions: Lerhamn, Nyhamnsläge, Viken, Hornbaek, Helsingör, Helsingborg. (Fig. 79)

Polyhalobe meioeuryhaline.

Porphyra purpurea (Roth) C. Ag.

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935).

Denmark: Kattegatt, Little Belt, Öresund.

The taxonomic status of *Porphyra purpurea* has long been disputed. Kornmann (1961 a) has shown that the conchocelis stage is different and Conway (1964) has on morphological and ecological grounds stated that it is a "good species". Pan-kow (1971) still considers it as a *f. laciniata* (Lightf.) J. Ag. of *Porphyra umbilicalis* (L.) Kütz.

This species is the most wide-spread of the *Porphyra* species in the Öresund area. It is common in the north part, frequent in the central part down to the line Helsingborg - Copenhagen and sparse to Landskrona - Dragör. South of this line no specimens have been found. *Porphyra purpurea* grows at sheltered or semi-exposed localities in the littoral zone from just above the 0-line down to about 0.5 m below. It grows on stones or more seldom on larger algae, e.g. fucoids.

The normal length of the thalli varies from (7) - 10 - 15 cm. Growth seems to be enhanced in polluted waters where specimens up to 50 cm long have been met with. The colour is purplish violet but light red in old specimens. The species is found throughout the year but can be killed by low water and cold weather during February and March. In such years new specimens reappear at the beginning of June. Growth is then very vigorous and normal size is reached within 10 - 14 days. Fertile specimens are found from June to November.

Localities: Hovs Hallar, Torekov, Hallands Väderö, Kullen, Mölle, Lerhamn, Nyhamnsläge, Viken, Gilleleje, Hornbaek, Helsingör, Helsingborg, Råå, Sletten, Ålabodarna, Ven, Landskrona, Tuborg, Tre Kroner, Dragör. (Fig. 79)

Polyhalobe mesoeuryhaline.

Porphyra umbilicalis (L.) J. Ag.

Distribution Sweden: Bohuslän, Kylin (1944); Kullen, Levring (1935).

Denmark: N. and E. Kattegatt; Copenhagen, Kristiansen (1972).

This species with its central holdfast is typical of tidal areas along the North Sea coasts where it is conspicuous in broad belts. It is in the Öresund area mainly found in the north part, where it is abundant to Nyhamnsläge - Gilleleje. South of this line it is sparse down to its south border between Ålabodarna and

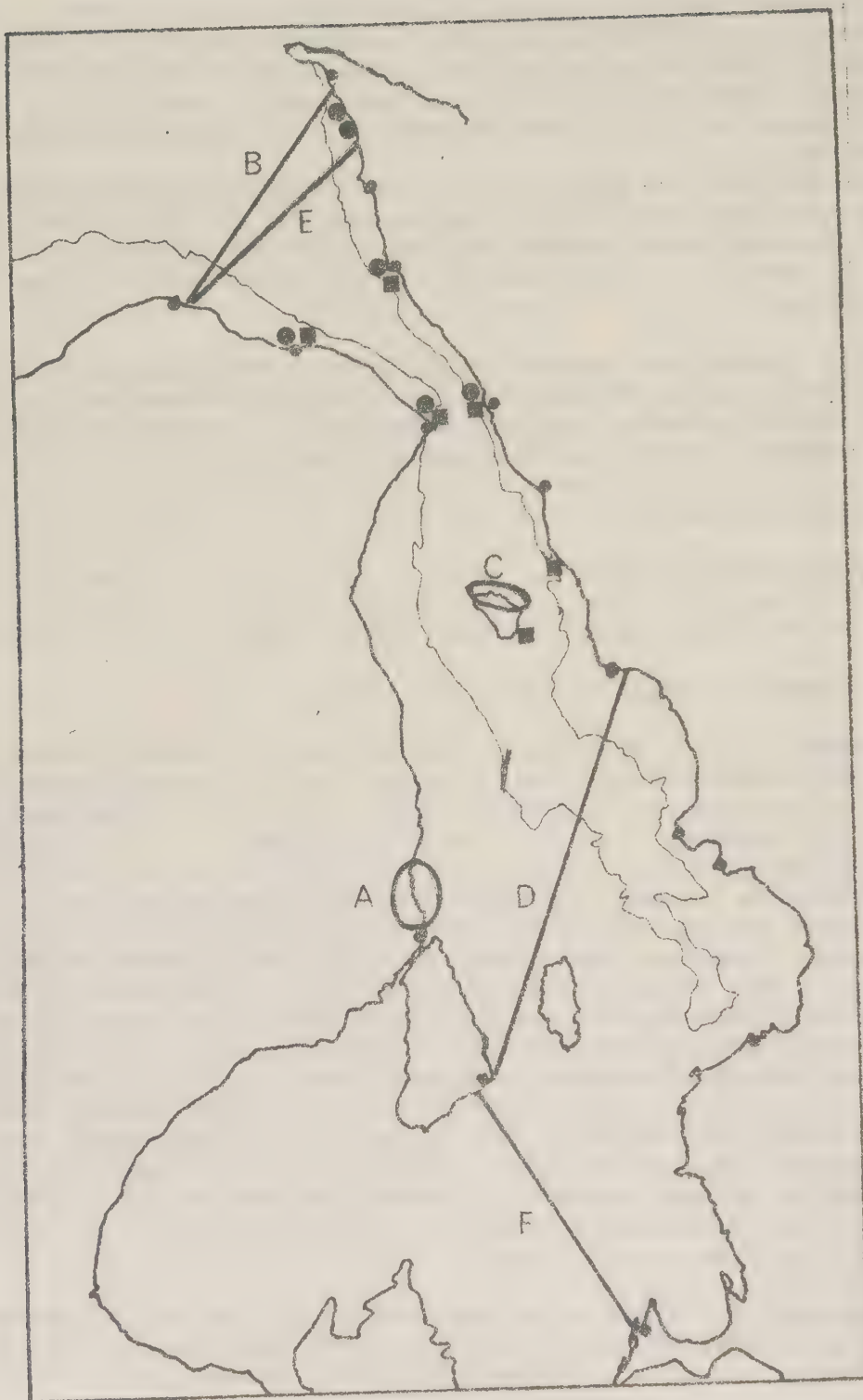


Fig. 79. The distribution of *Porphyra* species.

- A = Single specimens of *Porphyra leucosticta*
- B = The south border of belt-forming *Porphyra linearis*
- = Single specimens of *Porphyra linearis*
- C = Small belts of *Porphyra linearis*
- D = The south border of *Porphyra purpurea*
- E = The south border of belt-forming *Porphyra umbilicalis*
- = Single specimens of *Porphyra umbilicalis*
- F = The south border of the conchocelis stage

Copenhagen. *Porphyra umbilicalis* is found at exposed to semi-exposed localities in narrow belts from the 0-line to 0.25 m above. It is often seen to colonize bare rocks and new piers in a more expanded belt than normal, but when stable conditions are reached the breadth of the belt is restricted to its normal size. This suggests that the species has reduced ability to compete for space in the area.

The thalli are 6 - 10 cm long. The colour varies. Young specimens are blue-violet, older specimens olive green - light yellow. This probably depends more on age, light conditions and duration of desiccation than the degree of exposure to wave action as suggested by Conway (1964). The species is as a rule found throughout the year. In some years with cold winters it is either damaged by ice or killed due to desiccation (freeze-drying) by the prevalent low-water in combination with low temperature in February and March. Fertile specimens are found throughout the year but mainly from August to March.

Localities: Belt-formations: Hovs Hallar, Torekov, Hallands Väderö, Kullen, Mölle, Lerhamn, Nyhamnsläge, Gilleleje.
Single specimens: Viken, Hornbaek, Helsingör, Helsingborg, Ålabodarna, Ven. (Fig. 79)

Polyhalobe mesoeuryhaline.

The Conchocelis stage

Conchocelis is abundantly found in mollusc shells, e.g. *Cardium*, *Cyprina*, *Macoma*, *Mya*, *Mytilus*, and in balanides. They are common to the line Skanör - Dragör. This stage can apparently survive in somewhat lower salinity than the *Porphyra* stage. (Fig. 79)

FLORIDEOPHYCIDAE

NEMALIALES

Acrochaetiaceae

Acrochaetium

This large epiphytical genus with at least 150 known species of which many seem to be cosmopolitic, is still poorly known concerning species delimitation, morphology, ecology and distribution. The literature concerning the genus is large and difficult to encompass. The genus needs a revision combined with culture studies. *Acrochaetium* species are very common red algal epiphytes or endophytes in the Öresund.

Acrochaetium collopodum (Rosenv.) Hamel

Distribution Sweden: Bohuslän, Kristineberg, Kylin (1944); Kullen, Levring (1935).

Denmark: N. and middle Kattegatt, Little Belt, Öresund.

Acrochaetium collopodum is common in the north part of the area but is also frequently found in the central part. It grows in the littoral zone. The species is previously known to be an obligate epiphyte on *Chordaria flagelliformis*. In the Öresund it has also been found on *Leathesia difformis* in large numbers. (Fig. 80 A) As *Chordaria flagelliformis* is more widely distributed, the main part of *Acrochaetium collopodum*, however, is found on this host.

The thalli are 100 - 150 (-200) μ long. The cells are (4 -) 6 - 7 μ broad and twice as long with terminal hairs 2×40 μ . The species has been noticed from May to January. Monospores, 6 - 7 $\times$ 9 - 10 μ , are found from May to December.

Localities: Common in the north part; Barsebäck, Vikhög, Skogshoved, Tuborg.

Polyhalobe mesoeuryhaline.

Acrochaetium cytophagum (Rosenv.) Hamel

Distribution Sweden: Kullen, Levring (1935).

Denmark: Helsingör, Rosenvinge (1909), one find.

This species which was described by Rosenvinge (loc.cit.) from material collected at Helsingör, was for a long time known only from this locality. It must, however, have a large distribution area, as it has later been reported from Nova Scotia by Edelstein & McLachlan (1966). It is very easy to overlook. In the search for *Acrochaetium* species the author has examined a very large material of host algae. *Acrochaetium cytophagum* is probably very rare. It has only been found twice in small caves at Ransvik, Kullen, growing exposed but protected from direct sunlight at the O-line on old specimens of *Porphyra umbilicalis*. According to Rosenvinge (loc.cit.) *Acrochaetium cytophagum* should grow on or near the margin of the host but in the author's material the species grew all over the *Porphyra* "blade".

The thalli which were visible as small dots on the host, were 150 - 200 μ long with cells 6 - 10 μ broad and 2 - 3 times as long. The specimens agreed well with Rosenvinge's (loc.cit.) description. Both finds were made at the end of June (in 1966 and 1969), while Rosenvinge and Levring (loc.cit.) found the species in September. Both monospores, 6 - 8 x 10 - 15 μ , and tetrasporangia, 9 x 16 - 18 μ , were present on the same plant.

Locality: Kullen.

Polyhalobe meioeuryhaline.

Acrochaetium daviesii (Dillw.) Näg.

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935).

Denmark: Kattegatt, The Belts.

Though Levring (loc.cit.) only found the species once, it is frequently found in the north part of the area from 5 - 20 m in depth growing on *Antithamnion plumula*, *Ceramium rubrum*, *Halidrys siliquosa* and *Odonthalia dentata*.

Acrochaetium daviesii resembles *Acrochaetium thuretii* but is easy to distinguish from this by its shorter and more thick-walled cells. The thalli are 0.5 - 1 - (1.5) mm long and the cells 9 - 13 μ broad and 1.5 - 3 times as long. The species has been found from March to November. Monospores, 9 x 14 μ , 2 - 3 together on small branches, are found during the same time. On one occasion larger monospores, 12 x 25 μ , have been noticed. Tetrasporangia are very rare from March to June and occur together with monospores.

Localities: Off Hallands Väderö, Kullen, Mölle, Vattenmöllan, Höganäs, Gilleleje flack, Hornbaek Bay, Grälleggrund, Helsingborg, Barsebäck (one find).

Polyhalobe meioeuryhaline.

Acrochaetium dumontiae (Rosenv.) Hamel

Distribution Sweden: -

Denmark: Gilleleje and Helsingör, Rosenvinge (1909).

This species is similar to *Acrochaetium cytophagum* in its endophytical

growth, morphology, very rare appearance and badly-known distribution. The author has twice come across some single specimens of *Acrochaetium dumontiae* at Kansvik, Kullen, about 0.5 - 1 m below the 0-line on *Dumontia incrassata*. A possible explanation of the few finds of the species may be that it grows more abundantly on the deep-water specimens of *Dumontia incrassata*, which are more difficult to obtain in large numbers by dredging.

The plantlets were 300 - 500 μ long with only a few terminal hairs present. The cells were 7 - 8 x 20 - 24 μ . The finds were made at the beginning of May 1963 and in June 1968. The specimens bore numerous tetrasporangia, 7 - 11 x 13 - 18 μ .

Locality: Kullen.

Polyhalobe meioeuryhaline.

Acrochaetium emergens (Rosenv.) Web. Bosse

Distribution Sweden: -

Denmark: Skagerack, Rosenvinge (1909), one locality.

This endophytical species is very hard to find without maceration of the host. It is found rarely at some localities at Kullen from 5 - 22 m in depth, growing below the cortex cells in *Ceramium pedicellatum*, *Cystoclonium purpureum*, *Polysiphonia nigrescens*, *Polysiphonia urceolata* and *Polysiphonia violacea*.

The very narrow, sparsely branched filaments are 100 - 150 μ long. The cells are 2 - 3.5 μ broad and 2 - 3 times as long. The species is observed from March to July. Few monospores, 2 - 3.5 x 4 - 6 μ , have been found during the same period.

Locality: Kullen.

Polyhalobe meioeuryhaline.

Acrochaetium gynandrum (Rosenv.) Hamel

Distribution Sweden: Bohuslän, Kristineberg, Kylin (1944).

Denmark: N. Kattegatt, Little Belt (3 finds).

Very few finds of this species have been made in Scandinavia. It is recorded from a few localities in Norway by Sundene (1953) and Jaasund (1965), at 3 localities in Denmark by Rosenvinge (1909) and at Kristineberg by Kylin (loc.cit.).

In the Öresund the species has not been found before. It is apparently very rare in the area, only found on 3 occasions. Two of the finds were made at Kullen, about 10 specimens from 8 m in depth growing on *Ectocarpus confervoides* f. "typica" and a few specimens from 10 m in depth on *Polysiphonia violacea*. The third find is from the south Öresund, off Limhamn, where a few specimens were found from 6 m in depth on *Ectocarpus* sp.

The almost unbranched thalli vary from 150 - 200 μ in length with frequent short hairs. The cells are 4.5 - 6 x 9 - 12 μ . The species was observed from May to July. No sexual organs have been found but all specimens bore monosporangia, 5 - 7 x 10 - 12 μ .

Localities: Kullen, off Limhamn.

Polyhalobe mesoeuryhaline.

Acrochaetium hallandicum (Kylin) Hamel

Distribution Sweden: Bohuslän, Kristineberg and Halland: Fjordskär and Varberg, Kylin (1944); Kullen, Levring (1935); Blekinge, Levring (1940).

Denmark: Kattegatt, Samsö, The Belts, W. Baltic.

According to the author's opinion *Acrochaetium hallandicum* is quite distinct from *Acrochaetium parvulum*. On the other hand, it is possible that *Acrochaetium balticum* is conspecific with *Acrochaetium hallandicum* but the author has not seen enough material of the former to confirm this statement.

Acrochaetium hallandicum is frequently found in the north part of the Öresund from (7) - 10 - 20 m in depth on *Ceramium pedicellatum*, *Ceramium rubrum*, *Polysiphonia elongata*, *Polysiphonia nigrescens*, *Polysiphonia urceolata* and *Rhodomela confervoides*.

Compared to *Acrochaetium parvulum* the thalli of *Acrochaetium hallandicum* are longer, 500 - 700 μ . The cells are narrower and longer, 5 - 6 μ broad and 3 - 4 times as long, but the basal cells not as big as in *Acrochaetium parvulum*. *Acrochaetium hallandicum* is found from February to October. Monospores have been observed from May to September.

Localities: Off Hallands Väderö, Kullen, Gilleleje flack, Ellekilde hage, Hornbaek Bay, Grållegrund, Ven.

Polyhalobe pleioeuryhaline.

Acrochaetium humile (Rosenv.) Börgesen

Distribution Sweden: Kullen, Levring (1935); Blekinge, Levring (1940).

Denmark: Great Belt.

The species is found in abundance in the north and central part of the Öresund and in a few cases in the south part. It grows from just below the 0-line down to 15 m in depth on *Ceramium rubrum*, *Ceramium strictum* s.l., *Chaetomorpha aerea*, *Cladophora rupestris*, *Polysiphonia nigrescens*, *Rhodomela confervoides* and more seldom on *Zostera* leaves.

In the young stage *Acrochaetium humile* like *Acrochaetium leptonema* consists of a procumbent disc of creeping filaments. In very young stages the difference between the two species is subtle though the chromatophores are different. But after a short time when the procumbent discs have grown out the species is easily recognized. In *Acrochaetium humile* the monospores germinate into two large globular cells (Fig. 80 B). The corresponding cells in *Acrochaetium leptonema* are only slightly larger than the ordinary cells. The procumbent phase of *Acrochaetium leptonema* seems to be more regular in appearance than the disc of *Acrochaetium humile*. In both species erect filaments are numerous but at this stage the species are very easy to distinguish. The erect filaments of *Acrochaetium humile* consist as a rule of 3 - 4 cells, 4.5 - 7 x 9 - 18 μ . Young stages are only found in January and February, fully developed specimens from February to November. The monospores are terminal and 6 - 7 x 10 - 12 μ . They have been abundant from the beginning of April to November.

Localities: Hallands Väderö, Kullen, Ellekilde hage, Hornbaek Bay, Grållegrund, Helsingborg, Ven, Staffansbank, off Barsehäck, Klagshamn, Bredgrund.

Polyhalobe pleioeuryhaline.

Acrochaetium kylinii Hamel

Distribution Sweden: Halland, Morup and Hogartsgrund, Kylin (1907).

Denmark: -

Besides *Acrochaetium emergens* this species is one of the smallest epiphytical red algae and both are very difficult to detect. The distribution area is poorly

known. Pankow (1971) reports it from Warnemünde. The species has been found twice in the north part of the Öresund from about 20 m in depth on *Delesseria sanguinea*.

Acrochaetium kylinii consists of creeping filaments, 1.5 - 2.5 μ broad, which penetrate the space between the cells of the host, and erect filaments with a cell size of 2.5 x 2.5 - 6 μ . The total length of these filaments were 50 - 100 μ . The specimens agreed well with Kylin's (loc.cit.) description except that the filaments were somewhat shorter (150 μ according to Kylin). The two finds in the Öresund were made in September and December. Only a few terminal monospores, 5 x 6 - 7 μ , were found.

Localities: Kullen, Gilleleje.

Polyhalobe oligoeuryhaline.

Acrochaetium kylinioides Feldm.

Distribution Sweden: Bohuslän, Kristineberg, Kylin (1944); Kullen, Levring (1935).

Denmark: -

Kylin (loc.cit.) refers to *Kylinia rosulata* Rosenv. but his description of the species does not correspond with Rosenvinge's diagnosis (c.f. the chromatophore). Feldmann (1958) showed that Kylin's material represented a new species, *Acrochaetium kylinioides*. Pankow (1971) refers to this as *Kylinia kylinioides*(Feldm)Pankow. This inclusion in *Kylinia* cannot be correct since the genus *Kylinia* should have androphore cells according to Rosenvinge's diagnosis. Further, the depicted specimen in Pankow (loc.cit.) is not *Acrochaetium kylinioides*, which should have one basal cell (Fig. 80 C).

Acrochaetium kylinioides has been met with rarely in the north part of the Öresund from 0 - 10 m in depth on *Antithamnion plumula*, *Callithamnion fruticulosum*, *Chaetomorpha aerea* and *Ectocarpus confervoides* f. "typica".

As the species is only 40 - 50 μ in diameter and discoid with no erect filaments, it is easily overlooked. The cells are 4 - 8 x 6 - 14 μ . Specimens have been found from January to September. Monosporangia, 7 - 8 x 10 - 12 μ , have been observed from April to September.

Localities: Hallands Väderö, Kullen, Ellekilde hage, Grällegrund.

Polyhalobe mesoeuryhaline.

Acrochaetium leptonema (Rosenv.) Börgesen

Distribution Sweden: Kullen, Levring (1935); Blekinge, Levring (1940).

Denmark: Skagerack.

Acrochaetium leptonema is abundant in the north and central part of the Öresund and more sparse in the south part. It grows from just below the 0-line to 20 m in depth on *Ceramium pedicellatum*, *Ceramium rubrum*, *Chaetomorpha aerea*, *Cladophora rupestris*, *Polysiphonia elongata* and *Polysiphonia nigrescens*.

As stated above, juvenile stages of *Acrochaetium humile* and *Acrochaetium leptonema* can be hard to separate. But when upright filaments are found, there is no difficulty in separating the two species. The filaments of *Acrochaetium leptonema* are much longer, 150 - 250 μ . The cells are 3 - 5 μ thick and 2 - 4 times as long as broad. The species has been found throughout the year. Most of the finds are made from March to October. Juvenile stages alone are found in January and February. Monospores are 4 - 6 x 9 - 10 μ , mostly placed in the upper part of the filament. They have been seen in every month except January. (Fig. 80 D)

Localities: Hovs Hallar, Hallands Väderö, Kullen, Mölle, Ellekilde hage, Hornbaek Bay, Grållegrund, Helsingborg, Ven, Landskrona, Staffansbank, Barsebäck, Saltholm flack, Bredgrund.

Polyhalobe pleioeuryhaline.

Acrochaetium macula (Rosenv.) Hamel

Distribution Sweden: -

Denmark: Middle and S. Kattegatt, Samsö, Little Belt.

This species is found frequently in the north part of the area from 0.5 - 10 m in depth. It mostly grows on *Polysiphonia nigrescens*, but has also been recorded on *Polysiphonia urceolata* and *Polysiphonia violacea*.

Acrochaetium macula grows with monostromatic discs, 40 - 70 μ in diameter, and is easily overlooked. The cells are 4 x 4 - 7 μ . Hairs in low numbers are found in all observed specimens. The species is noticed from April to September. All specimens bore monospores, 5 - 7 x 9 - 12 μ . (Fig. 80 E)

Localities: Hallands Väderö, Kullen, Lerhamn, Höganäs, Grållegrund.

Polyhalobe mesoeuryhaline.

Acrochaetium moniliforme (Rosenv.) Kylin

Distribution Sweden: Bohuslän, Kristineberg, von Wachenfeldt (unpubl.); Kullen, Levring (1935).

Denmark: N. and S. Kattegatt, Samsö, Little Belt, Öresund, W. Baltic, Baltic Möen.

This easily identified *Acrochaetium* species was found for the first time in Sweden by Levring (loc.cit.): "Diese Alge habe ich während des Sommers bei mehreren Gelegenheiten angetroffen." The species has been found a few times in the north and central part of the Öresund. It is apparently not frequent in the area. It grows from 0.2 - 15 m below the 0-line on *Polysiphonia brodiaei*, *Polysiphonia elongata* and *Polysiphonia nigrescens* together with *Acrochaetium hallandicum*, *Acrochaetium parvulum* and *Acrochaetium polyblastum*.

The species is in most cases completely attached to the surface of the host. The filaments are 50 - 100 μ long and the cells almost round, 5 - 10 μ in diameter. The basal cell is of about the same size as the other cells. The species has been observed from May to August. The unilaterally placed spores, 6 - 8 x 12 - 16 μ , are seen in June and July.

Localities: Kullen, Ellekilde hage, Ven.

Polyhalobe meioeuryhaline.

Acrochaetium parvulum (Kylin) Hoyt

Distribution Sweden: Bohuslän, Kristineberg and Halland, Fjordskär, Varberg, Kylin (1944); Kullen, Levring (1935); Blekinge, Levring (1940).

Denmark: Kattegatt, Smålandshavet, Öresund.

Like *Acrochaetium hallandicum* the delimitation of *Acrochaetium parvulum* is not quite clear. According to Kylin (loc.cit.) *Acrochaetium rhipidandrum* Rosenv. and *Acrochaetium hallandicum* f. *parvula* Rosenv. are conspecific with *Acrochaetium parvulum* Kylin. Lund (1959 a) is not convinced that "the species ought to be kept

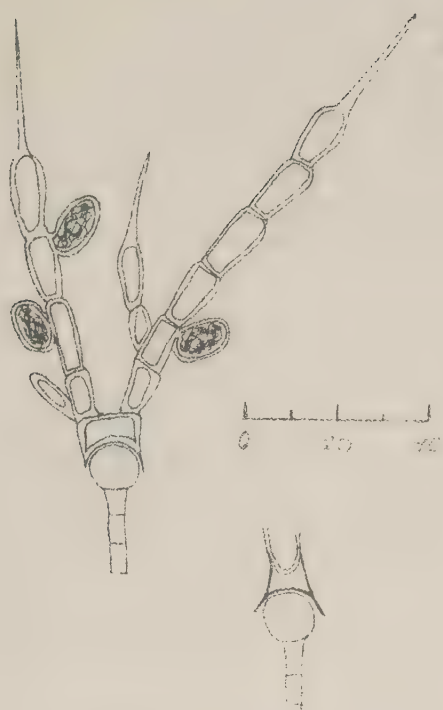


Fig. 80 A. *Acrochaetium collopodum*,
growing on *Leathesia*
difformis.

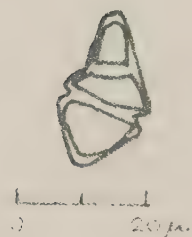


Fig. 80 B. *Acrochaetium humile*,
young stage.

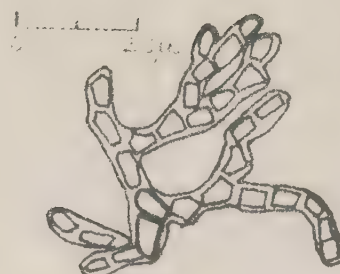


Fig. 80 D. *Acrochaetium leptonema*,
young stage.

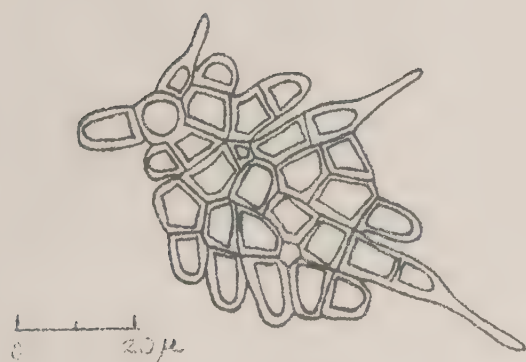


Fig. 80 C. *Acrochaetium kyrioides*.

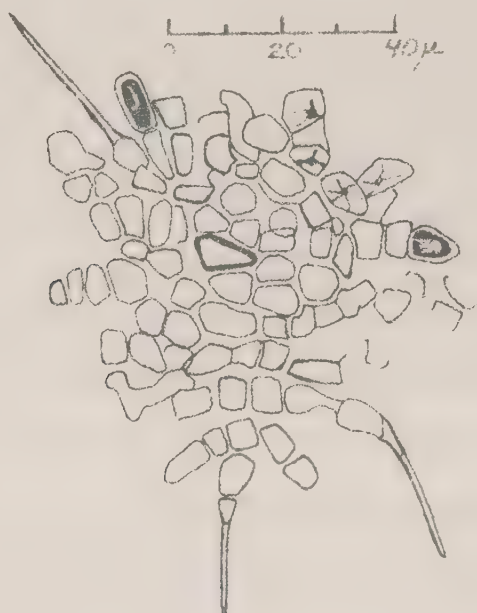


Fig. 80 A - E. *Acrochaetium*
species.

Fig. 80 E. *Acrochaetium macula*.

distinct from *Acrochaetium hallandicum*". Jaasund (1965) states, "the delimitation between *Acrochaetium parvulum* and *Acrochaetium hallandicum* is not clear". Kylin (loc.cit.) was of the opinion that Levring's *Acrochaetium parvulum* from Kullen was "nichts anderes als *Kylinia rosulata*" (= *Acrochaetium kylinioides* Feldm.). The author is quite convinced that *Acrochaetium parvulum* and *Acrochaetium hallandicum* are two distinct and well-separated species, concerning cell size, morphology and ecology. The author has examined Levring's material from Kullen and found that the major part of the specimens are really *Acrochaetium parvulum*. But the specimens that Levring (1935, 1940) has depicted may be the true *Kylinia rosulata* or *Acrochaetium kylinioides*.

Acrochaetium parvulum is without doubt the most common epiphytic red alga in the Öresund. It is common in the whole area but probably a little more conspicuous in the north part. The species seems to be less abundant or lacking in highly polluted areas. It is found from 0 - 10 - (15 - 20) m in depth on many different hosts, e.g. *Ceramium rubrum*, *Ceramium strictum* s.l. (most conspicuous), *Cladophora* sp., *Delesseria sanguinea*, *Dictyosiphon foeniculaceus*, *Enteromorpha* sp., *Leathesia difformis*, *Phycodrys rubens*, *Polysiphonia elongata*, *Polysiphonia nigrescens*, *Polysiphonia urceolata* and *Polysiphonia violacea*. Kylin's (loc.cit.) statement that the species is an obligate epiphyte on *Porphyra purpurea* does not seem to be correct.

The thalli are 50 - 200 - (250) μ long and the cells 5 - 8 x 10 - 20 μ . The species is found throughout the year. Monospores, 8 - 15 x 14 - 20 μ , are observed from February to November. (Fig. 81 A)

Localities: Common in the whole area except the southernmost part.

Polyhalobe pleioeuryhaline.

Acrochaetium pectinatum (Kylin) Hamel

(*Audouinella pectinata* (Kylin) Papenf.)

Distribution Sweden: Bohuslän, Kristineberg, Levring (1935 b); Halland, Hogartsgrund, Varberg, Kylin (1907); Kullen, Levring (1935).

Denmark: N. and E. Kattegatt, Little Belt.

According to Rosenvinge (1909) this species is closely related to *Audouinella efflorescens*. It has also been transferred to this genus by Papenfuss (1947).

Acrochaetium pectinatum is probably sparse or even rare along the Swedish coast. In the Öresund it is only found at three localities in the north part in very low numbers from 10 - 20 m in depth. It has been found on *Ceramium* sp. and *Desmarestia aculeata*.

The plant is 1 - 2 mm high, the cells being 5 - 6 μ broad and 5 times as long, thus somewhat reduced compared with specimens from Bohuslän (Levring, 1935 b). The finds are made in May and June. Monospores, 4.5 - 7 x 9 - 12 μ , have been found on all examined specimens.

Localities: Off Hallands Väderö, Vattenmöllan, Ellekilde hage.

Polyhalobe meioeuryhaline.

Acrochaetium polyblastum (Rosenv.) Börgesen

Distribution Sweden: Kullen, Levring (1935).

Denmark: N. Kattegatt.

Acrochaetium polyblastum is common in the north part of the Öresund where it grows conspicuously from 0.5 - 2 - (20) m in depth on *Ceramium rubrum*, *Polysiphonia*

nigrescens and Rhodomela confervoides. In the first metres of the sublittoral zone it can easily be detected by the naked eye, as the host is quite overgrown and looks "shaggy". Below 3 m only single specimens have been found.

This interesting Acrochaetium species with partly procumbent, partly erect filaments is easy to distinguish from other species by being heavily branched and having numerous hairs and tetrasporangia. With increasing depth the number of hairs is reduced. The growth of hairs is probably induced by light and thus not a good taxonomical feature. The erect filaments are 150 - 200 μ long and the cells 8 - 10 x 24 - 30 μ . The colour of the epiphyte is brown - red. Acrochaetium polyblastum is a spring alga with a very short vegetation period from April to June. The tetrasporangia are 8 - 9 x 12 - 14 μ and found during the whole vegetation period.

Localities: Hallands Väderö, Kullen, Vattenmöllan, Hornbaek Bay, Grålleggrund, Helsingborg.

Polyhalobe mesoeuryhaline.

Acrochaetium reductum (Rosenv.) Hamel

Distribution Sweden: Bohuslän, Kristineberg, Kylin (1944); Kullen, Levring (1935).

Denmark: N. Kattegatt.

Acrochaetium reductum is frequently found in the north part of the area growing from just below the 0-line to 25 m in depth on Ceramium pedicellatum, Ceramium rubrum, Polysiphonia brodiaei, Polysiphonia elongata, Polysiphonia nigrescens and Rhodomela confervoides.

This extremely reduced Acrochaetium species is very easy to overlook. The creeping filaments partly penetrate the space between the host cells. From the creeping threads grow erect, branched filaments, 2 - 3 cells long, with unstalked monosporangia. Like Acrochaetium humile the two primary cells are greater than the following ones. The cells in the creeping filaments are 3.5 - 4 x 5 - 8 μ . The erect filaments are somewhat thicker, 4.5 - 5.5 x 4.5 - 7 - (8) μ and (1) - 2 - 3 cells long. Hairs are common. The species is found from December to August. Monospore-bearing plants are in the majority and are found from February to August. The monospores are 5 - 6 x 7 - 9 μ . In a minor part of the material plants with only tetrasporangia have been recorded. In a few cases both monospores and tetraspores are found on the same specimen.

Localities: Off Hallands Väderö, Kullen, Mölle, Hornbaek Bay, Grålleggrund, Helsingborg.

Polyhalobe mesoeuryhaline.

Acrochaetium secundatum (Lyngb.) Näg.

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935).

Denmark: N. Kattegatt (one find).

Besides Acrochaetium parvulum this species is one of the most common epiphytic red algae. It is commonly found in the north part of the Öresund and around Ven. It grows from the 0-line down to 15 - (20) m in depth on Cladophora rupestris, Ulva lactuca, along the margins of Porphyra purpurea but is most conspicuous on Ceramium rubrum, Ceramium strictum s.l. and Polysiphonia sp.

The plant is 0.5 - 1 mm high and the cells 10 - 12 μ broad and 2 - 3 times as long. The species has been found during the whole year. From September to May it is only seen in low numbers. In May the species grows vigorously and can more or less cover the host completely. In the end of August most of the specimens seem

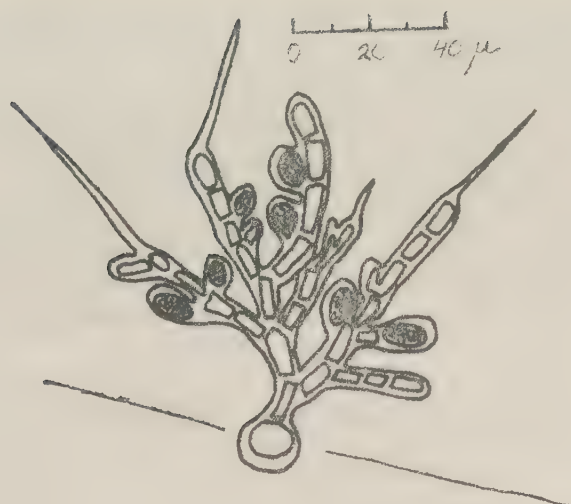


Fig. 81 A. *Acrochaetium parvulum*.

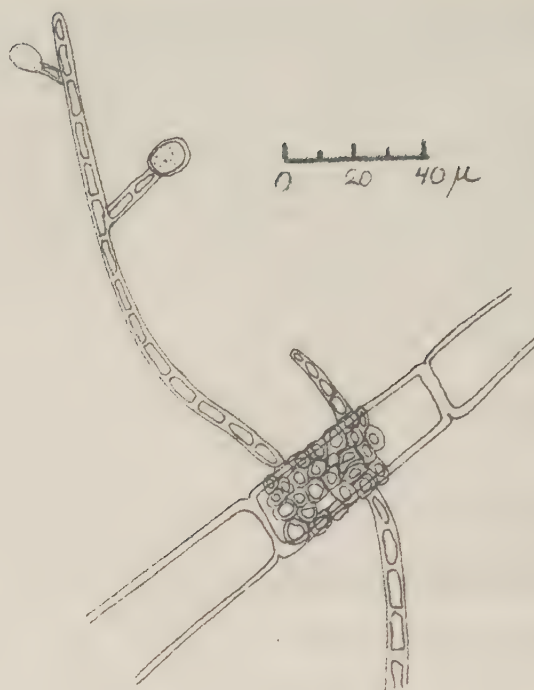


Fig. 81 B. *Acrochaetium strictum*.

Fig. 81 A - B. *Acrochaetium* species.

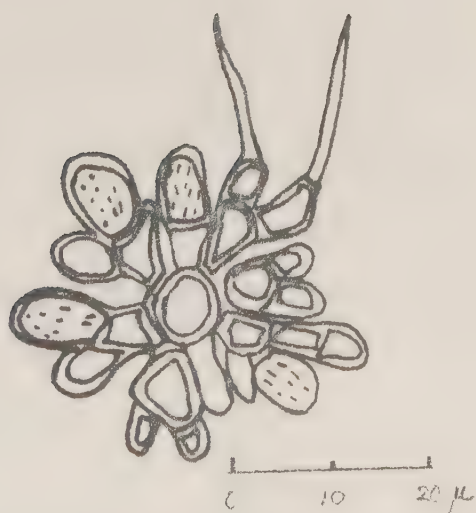


Fig. 82 A.

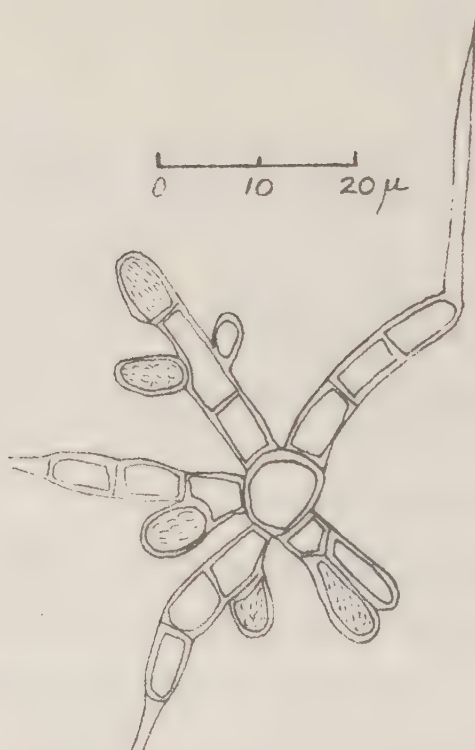


Fig. 82 B.

Fig. 82 A - B. *Kylinia rosulata*.

to die. Monospores, $10 - 15 \times 15 - 20 \mu$, are borne in the apex of small branches and are conspicuous during the whole year. Tetrasporangia in low numbers occur from May to July.

Localities: Torekov, Hallands Väderö, off Hallands Väderö, Kullen, Vattenmöllan, Gilleleje, Hornbaek Bay, Grållegrund, Helsingborg, Ven.

Polyhalobe mesoeuryhaline.

Acrochaetium strictum (Rosenv.) Hamel

Distribution Sweden: Bohuslän, Kristineberg, Kylin (1944); Kullen, Levring (1935).

Denmark: Middle and S. Kattegatt, Samsö.

Acrochaetium strictum is frequently found, though in low numbers, in the north part of the Öresund, where it grows from 2 - 20 m in depth on *Ceramium arborescens*, *Ceramium strictum* s.l., *Polysiphonia elongata*, *Polysiphonia nigræscens* and *Spermothamnion repens*.

This species has erect filaments with few or no branches but with small branchlets consisting of one or two cells. A somewhat atypical *Acrochaetium strictum* found on *Spermothamnion repens* is depicted in Fig. 81 B. The filaments of *Acrochaetium strictum* are 0.5 - 1 mm long and the cells are 5 - 6 μ broad and 3 - 4 times as long. The species is found from April to October but is most prominent in July and August. Monospores, $6 - 7 \times 10 - 14 \mu$, have been observed during the whole vegetation period.

Localities: Kullen, Mölle, Vattenmöllan, Hornbaek Bay, Grållegrund.

Polyhalobe meioeuryhaline.

Acrochaetium thuretii (Born.) Coll. et Herv.

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935).

Denmark: Kattegatt, Samsö, The Belts.

This species is sparsely found in the north part of the Öresund but when found it often occurs in great numbers. It only grows in the lower part of the sublittoral zone from 10 - 15 - 25 m in depth on *Ceramium pedicellatum*, *Cystoclonium purpureum*, *Delesseria sanguinea* and *Halidrys siliquosa*.

The plant is 1 - 2 mm long, the cells 6 - 8 - (9) μ broad and 4 - 9 times as long. The species is found from February to October. The monospores are $8 - 12 \times 13 - 16 \mu$, on one occasion $8 \times 35 \mu$, and are observed from April to October. Specimens with both carpogonia, spermatangia and monospores have been found from May to July.

Localities: Off Hallands Väderö, Kullen, Vattenmöllan, Höganäs, Hornbaek Bay, off Helsingborg. (Fig. 83)

Polyhalobe meioeuryhaline.

Acrochaetium virgatulum (Harv.) J. Ag.

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935); Blekinge, Levring (1940); Småland and Gotland, Svedelius (1901).

Denmark: All districts except W. Baltic.

This cosmopolitic species is common in the whole of Öresund from 0.2 - 25 m in depth growing on *Ceramium rubrum*, *Ceramium strictum* s.l., *Ectocarpus* sp., Poly-

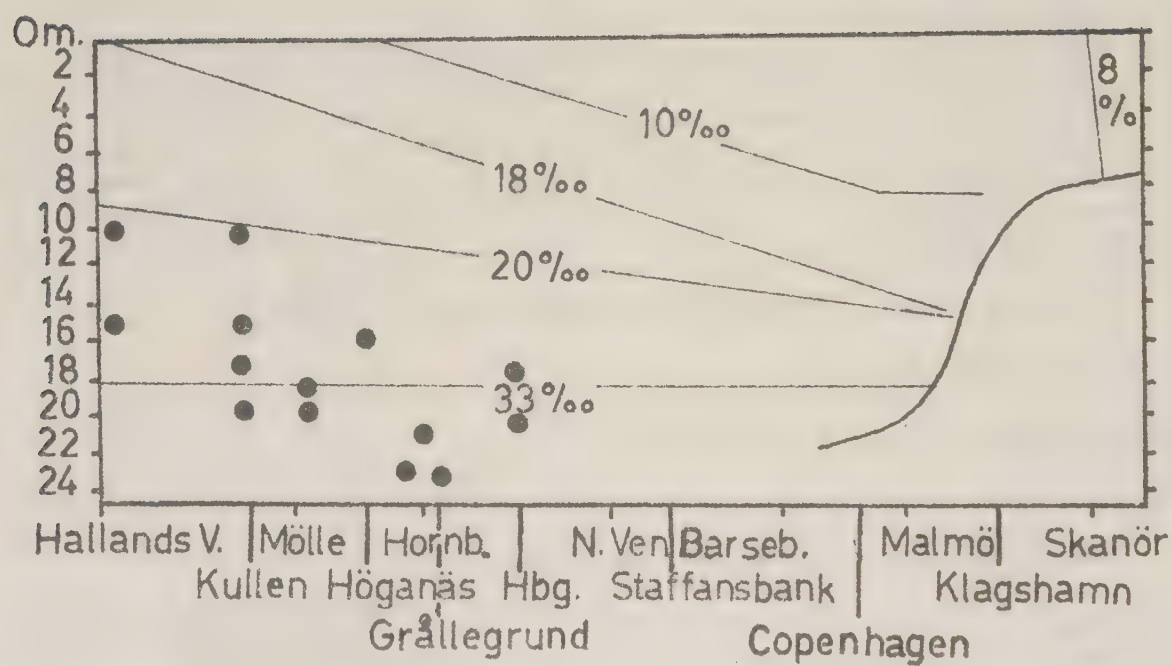


Fig. 83. The distribution of *Acrochaetium thuretii* in relation to depth and salinity.

siphonia elongata, Polysiphonia violacea and Rhodomela confervoides but not on Zostera leaves as found by many authors.

The plants are 1 - 2 mm long and the cells 12 - 14 μ broad and 3 - 4 - (5) times as long. The species is found from April to December. Monospores, 9 - 12 x 12 - 16 μ , are observed during the whole vegetation period.

Localities: Common in the whole area.

Polyhalobe pleioeuryhaline.

Audouinella efflorescens (J. Ag.) Papenf.

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935); Blekinge, Levring (1940); Öregrund, Waern (1952).

Denmark: All districts except Smålandshavet and Baltic Möen.

According to the literature this species has a somewhat remarkable distribution. Kylin (loc.cit.) states, "längs der ganzen West-Küste verbreitet, spärlich, stellenweise doch häufig". In Blekinge Levring (1940) writes "nur bei Ronneby gefunden und sie dürfte ausserst selten sein". Waern (loc.cit.) states "Audouinella efflorescens is strongly pauperized within the Öregrund archipelago but this is by no means a rare alga".

In the Öresund Audouinella efflorescens is frequently found in the north part of the area and sparsely in the central part. No finds have been made in the south part of the area though it is widely distributed in the Baltic. It has been obtained from 10 - 25 m in depth on Chondrus crispus, Cystoclonium purpureum, Desmarestia aculeata, Purcellaria fastigiata, Halidrys siliquosa and on hydroids.

The plantlets are about 1.5 - 2 - (3) mm long, the cells are 4.5 - 5.5 μ broad and 6 - 14 times as long. The species is found from March to November. No sexual plants have been observed but most of the specimens have borne tetrasporangia, 7 - 10 x 13 - 24 μ , and in a few cases also monospores, 5 - 7 x 10 - 17 μ .

Localities: Off Hallands Väderö, Kullen, Vattenmöllan, Hornbäck Bay, Grållegrund, Helsingborg, Staffansbank, off Barsebäck.

Polyhalobe pleioeuryhaline.

Audouinella membranacea (Magn.) Papenf.

(Rhodochorton membranaceum Magn.)

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935).

Denmark: All districts except Smålandshavet and the Baltic proper.

This species is common in the whole of Öresund. It is found from just below the 0-line to 27 m in depth in different species of hydroids, most conspicuously in Dynamena pumila.

The cells are very variable in size, 4 - 11 μ broad and 1 - 8 times as long. The species is found during the whole year. Filaments which have penetrated the epidermis of the host are frequently found, and these filaments possess tetrasporangia.

Localities: Common in the whole area.

Polyhalobe mesoeuryhaline.

Kylinia rosulata Rosenv.

Distribution Sweden: -

Denmark: N. Kattegatt.

The real *Kylinia rosulata* is not recorded with certainty from Sweden before, as Kylin's *Kylinia rosulata* is proved to be *Acrochaetium kylinioides* Feldm. Pankow (1971) must have made an error when he states "Chromatophor zentral, sternförmig, mit zentralem Pyrenoid", and gives the distribution "Westküste Schwedens" but judging from Pankow's (loc.cit.) drawing and photograph it may be Rosenvinge's *Kylinia rosulata* which he has observed.

Kylinia rosulata has been found a few times in the Öresund growing from 1 - 10 m in depth on *Ceramium strictum* s.l. and *Ectocarpus* sp.

The specimens are firmly attached to the cell walls of the host and no erect cells are found except in one case, when light and almost colourless upright cells, about $2 \times 6 - 8 \mu$, have been noticed. These cells are most probably androphore cells, spermatophores according to Feldmann (1958). The diameter of the whole plant is $40 - 50 \mu$ and the cells are $(3.5) - 4 - 5 \times 6 - 10 \mu$. The species has been met with from May to September. No spermatangia have been observed. The monospores are as a rule lateral and $7 \times 11 - 12 \mu$. Monospores are found during the whole time and androphore cells in September. (Fig. 82 A - B)

Localities: Kullen, Grållegrund, Bredgrund.

Polyhalobe mesoeuryhaline.

Rhodochorton penicilliforme (Kjellm.) Rosenv.

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935).

Denmark: Kattegatt, Samsö, The Belts, W. Baltic.

According to Kylin (loc.cit.) the species is, "längs der ganzen Westküste verbreitet aber sehr spärlich". In the Öresund the species is abundant in the north and central part. South of Malmö only a few finds have been made. It grows from $(0.5) - 5 - 27$ m in depth, but most abundantly at depths of $10 - 20$ m, mainly on *Chaetomorpha melagonium*, but also on *Cladophora rupestris*, *Desmarestia aculeata*, *Halidrys siliquosa*, *Phyllophora brodiaei* and *Phyllophora membranifolia*.

The total length of the erect filaments is $1 - 1.5 - (2)$ mm and the cells are $12 - 15 \mu$ broad and $2 - 3$ times as long. The species has been found throughout the year. In January only juvenile stages with the characteristic basal disc and very short, sterile erect filaments have been found. Tetrasporangia, $24 - 27 \times 30 - 32 \mu$, have been met with from April to November.

Localities: Hallands Väderö, off Hallands Väderö, Kullen, Vattenmöllan, off Lerhamn, Gilleleje flack, Ellekilde hage, Hornbaek Bay, Grållegrund, Helsingborg, Staffansbank, off Farsebäck, off Malmö, W. Limhamn.

Polyhalobe mesoeuryhaline.

Rhodochorton purpureum (Lightf.) Rosenv.

(Rhodochorton rothii (Turt.) Näg.)

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935); Blekinge, Levring (1940); Gotland, Svedelius (1901); Öregrund, Waern (1952).

Denmark: All districts except Smålandshavet and W. Baltic.

Rhodochorton purpureum is common in the north and central part and sparse in the south part of the Öresund. The species is found at two different levels, partly in the supralittoral and littoral zone and partly in the lower part of the sublittoral zone. In the supralittoral zone the species grows up to 6 m above the 0-line on stones in caves where they are protected from direct sunlight and there is a constant high relative humidity. As a rule one can only find small patches, but in a large cave at Kullen about 10 m² is covered with *Rhodochorton purpureum*. In the littoral zone the species grows from the 0-line to 0.5 m below on stones in small patches shaded by fucoids and other algae. In the sublittoral zone it grows between (7) - 10 - 25 m in depth epiphytically on *Halidrys siliquosa*, *Laminaria stipes* and to a smaller extent on other algae.

The total length of the filaments is 2 - 3 mm and the cells are 9 - 13 μ broad and 2 - 3 times as long. The species is found during the whole year. The tetrasporangia are 12 - 14 x 18 - 26 μ . Specimens growing in the supralittoral and littoral zone have tetrasporangia from January to May - (June) and specimens in the sublittoral zone from September to January.

Localities: Common in the north and central part; Kalkgrundet, W. Klagshamn, Bredgrund.

Polyhalobe pleioeuryhaline.

The effects of some environmental factors on the distribution of *Rhodochorton purpureum* in the supralittoral zone.

The author has tried to determine the main a-biotic environmental factors for *Rhodochorton purpureum* in the supralittoral zone at one locality at Kullen. The species here grows in patches from 0.5 - 3 m above the 0-line in a cave with the entrance towards NNW. The measurements were made during a 24 hours period around the summer solstice. The reason for this was that this is the only period during the whole year when the sun can penetrate directly into the cave, which occurs around 6.30 - 8.00 p.m. Shorter measurements have been made regularly at other times during the year which showed that results from the main measurement period had the highest temperature and light intensity and the lowest relative humidity and thus ought to represent the most unfavourable situation during the year.

The temperature was measured with copper-constantan thermoelements in connection with a recorder. The sensors were secured in the "algal felt" of different *Rhodochorton* patches and in the air at the entrance to the cave. The relative humidity was measured every half hour in the *Rhodochorton* patches and in the air at the entrance to the cave with precision hair-hygrometers which were controlled against an Assman hygrometer every hour. The light was measured every half hour with a luxmeter at the same places as the other parameters.

The results of the measurements from three of the *Rhodochorton* patches are shown in Fig. 84 A - C. One of the patches was situated near the entrance of the cave and showed poor growth. The other two were growing further into the cave and were well-developed.

The temperature in the *Rhodochorton* patches (Fig. 84 A) was relatively constant, varying from 12.5 to 16.0 °C, except for about one hour in two of the patches, where the temperature rose to 16.5 - 17.5 °C, when the sunlight penetrated into the cave for a short period. The temperature was simultaneously measured at several places within the cave, where there was no *Rhodochorton*. The temperature conditions were here the same as in the algal patches. Other measurements during the year have shown that there are no temperature differences between the patches except for June, July and August and even during summer the differences are never as large as in the diagram.

The relative humidity varied for the two patches in good health between 88 and 95 % during most of the time, although the relative humidity in the air outside the cave in the afternoon was as low as 40 - 50 % (Fig. 84 B). When the sun reached the patches, the relative humidity sank for about one hour. During the rest of the summer the values were never below 85 % and during the remaining part of the

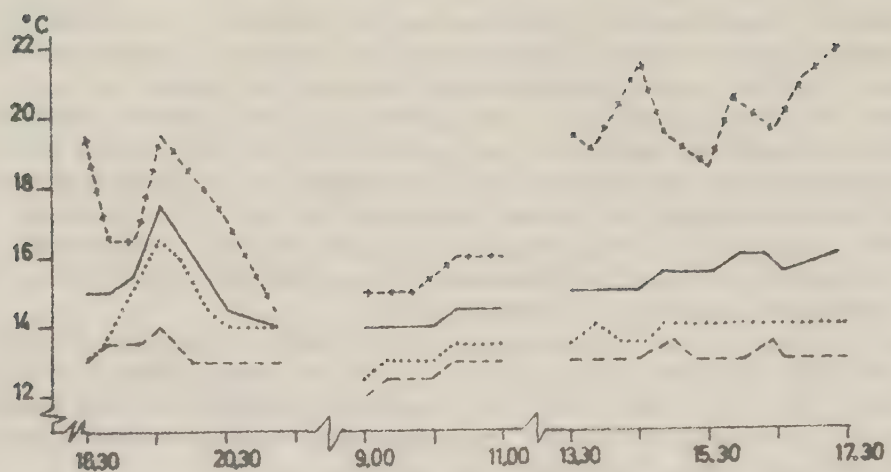


Fig. 84 A. Temperature.

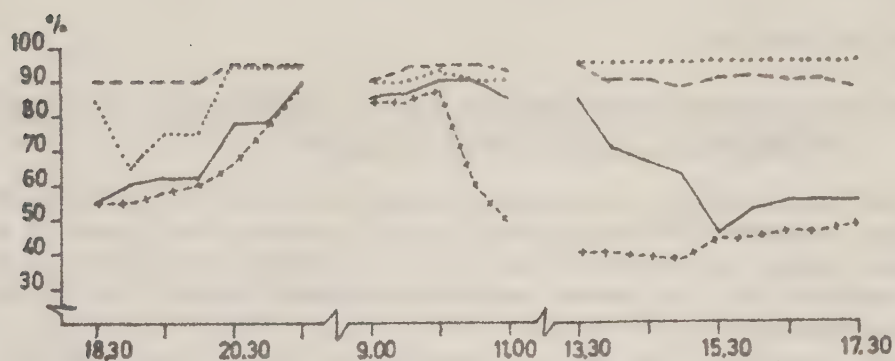


Fig. 84 B. Relative humidity.

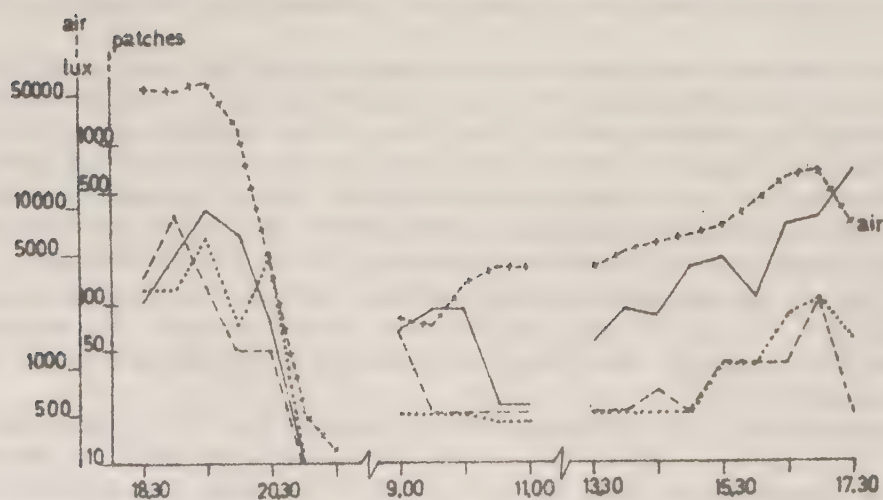


Fig. 84 C. Light intensity.

Fig. 84 A - C. Measurements of some environmental factors of importance to the distribution of *Rhodochorton purpureum* in a cave at Kullen 24/6 and 25/6 1967.

--- air at the entrance of the cave
 patches of *Rhodochorton purpureum*

year they varied between 90 and 100 %.

The light conditions showed the greatest variation (Fig. 84 C). The light which reached the patches varied between 0 and 630 lux. During the rest of the summer the light intensity varied from 0 to 600 lux and during the rest of the year from 0 to 200 lux.

The author is of the opinion that the relative humidity and the light intensity are the major factors limiting the distribution of *Rhodochorton purpureum* in the supralittoral zone, while the temperature is of less importance.

Helminthocladiaceae

Nemalion multifidum (Web. et Mohr) J. Ag.

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935); Limhamn, Sjöstedt (1928 a).

Denmark: All districts except Bornholm.

The taxonomic status of *Nemalion multifidum* and *Nemalion helminthoides* is disputable. Dixon (1964), Womersley (1965) and Hollenberg & Abbott (1966) have independently come to the conclusion that the two species are conspecific. Söderström (1970) has reviewed the complex and found them to be distinct species. The author, who has studied *Nemalion helminthoides* in the Mediterranean, quite agrees with Söderström.

Nemalion multifidum has an interesting distribution in the Öresund, which apparently is well correlated with the salinity conditions. It forms a belt in the northernmost part of the Öresund at exposed or very exposed localities (Fig. 103) from about (20) - 10 cm above the 0-line to 10 cm below. The breadth and density of the belt is correlated with the degree of exposure to wave action. The species reappears in belts on the north part of Ven in the central Öresund (Fig. 85) where the salinity is locally higher due to upwelling bottom water. South of the line Lerhamn - Gilleleje single specimens of normal appearance can be found in low numbers but south of Viken - Helsingör the species grows differently: at sheltered localities, only 2 - 4 cm high and in the later part of October and November. The delay in development is most probably due to the lower salinity and the development is triggered by the increasing salinity in October and November (cf. Fig. 14). Normally developed *Nemalion* have not been found in sheltered positions as stated by Steemann Nielsen (1951) and Söderström (loc.cit.).

The specimens are fully developed 10 - 12 cm long. According to Kylin (loc. cit.) the normal length in Bohuslän is 10 - 20 cm. Rosenvinge (1909) reported from Gilleleje a specimen which was 40 cm long. The first sign of belt-forming *Nemalion multifidum* is found at the end of June and the beginning of July. Maximum development is reached in the later part of August. Already in late September most of the specimens begin to decay and as a rule no trace of the species can be found by the end of October. On one occasion comparatively "fresh" but sterile specimens were found in the middle of January.

In the north part of the area fertile specimens are found in August and September. As a rule both spermatangia, carpogonia and ripe gonimoblasts can be found on the same plant throughout the fertile period. In the south part of the area fertile specimens are found in October and November. Hamel (1930) i.a. stated that the species was mostly monoecious. Rosenvinge (loc.cit.) and Kylin (1916) reported that the major part of the Scandinavian material was dioecious. Söderström (loc.cit.) has discussed these matters and divided the species into two subspecies, ssp. *multifidum* (the dioecious form) and ssp. *monoicum*. The Swedish population should, according to Söderström, belong to ssp. *multifidum*. The author has the impression that in the Öresund at least 25 % of the examined material is monoecious. If they are only pseudomonoecious, sensu Söderström, is hard to say.

Söderström (loc.cit.) refers to an experiment with sterilized stones which were laid out in April and later were covered by *Nemalion multifidum* in the normal way. The author has made observations of similar things but with different results. The jetty of the harbour of Lerhamn, which had a normal *Nemalion* belt in August



Fig. 85. The distribution of *Nemalion multifidum*.

- A = The south border of belt-forming *Nemalion multifidum*
- B = Local area of belt-forming *Nemalion multifidum*
- = Single specimens
- = According to Rosenvinge (1909)

and September, was rebuilt and new stones were laid on the vegetation in the autumn. On the new stones no trace of *Nemalion* could be found for the next two years. These observations show that *Nemalion multifidum* in the north part of the Öresund has a low ability to spread to or colonize new areas. This may be interpreted such that either the diaspores or the juvenile stages are injured by low salinity. This will of course reduce the ability of the species to compete for space.

In November 1965 and January 1966 the author found a lot of red moniliform curling filaments growing about 10 - 30 cm above the 0-line, entangled in *Calothrix* sp. The cells in the filaments were $4 \times 10 \mu$, with monospores, and resembled sterile *Nemalion* filaments (Fig. 86). These were with some hesitation interpreted as a stage of the tetrasporophyte of *Nemalion multifidum*. This proved to be correct when Fries (1967) published her most interesting work on the life-cycle of *Nemalion multifidum*.

Localities: Belt forming: Hovs Hallar, Torekov, Hallands Väderö, Kullen, Mölle, Lerhamn, Gilleleje, Ven.

Single specimens at sheltered localities: Viken, Helsingborg, Bäckviken, S. Ven, Taarbaek, Barsebäck, Limhamn. (Fig. 85).

Polyhalobe mesoeuryhaline.

Bonnemaisoniaceae

Bonnemaisonia hamifera Hariot

(*Trailliella intricata* stage)

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Hallands Väderö, Suneson (1939 a).

Denmark: Kattegatt.

This alga, which was originally described by Batters in 1896, has in a remarkable way expanded its distribution area in western Europe. In Scandinavia it was first met with in Limfjorden by Rosenvinge in 1901 and in Bohuslän by Kylin in 1905. Both Rosenvinge and Kylin proved that the species was new in these areas. Suneson (loc.cit.) recorded the species from Hallands Väderö.

The author found *Trailliella intricata* at Suneson's locality in 1962. The first record from the Öresund proper was made in the north part in 1964. During the years 1965 - 1968 the species was found at many localities in the Öresund down to Lomma Bay, where a few finds were made. At some localities in the north part of the area it was fairly common in 1966 and 1967. From 1968 onwards very few finds have been made. The species grows from (10) - 15 - 25 m in depth on *Furcellaria fastigiata* and *Odonthalia dentata* and entangled in the hapters of *Laminaria* sp. The species often but not always grows together with *Spermothamnion repens*.

The filaments are 1 - 4 mm long and 20 - 30 μ broad (Fig. 87). Typical "Trailliella balls" up to 3 cm in diameter which are found in the north of Kattegatt have only been found at Gilleleje flack but with a maximum diameter of 1.5 cm. The number of the typical glandular cells is reduced in the Öresund area, most markedly in the south part of the distribution area. The specimens found in Lomma Bay contained hardly any glandular cells at all. Culture studies of material, collected in Hornbaek Bay, and grown at a constant high salinity of 34 - 35 ‰ for several months, showed a normal number of glandular cells. *Trailliella intricata* has been found throughout the year, but only sterile filaments have been observed.

Localities: Off Hallands Väderö, Kullen, Mölle, Vattenmöllan, Gilleleje flack, Ellekilde hage, Hornbaek Bay, Grållegrund, off Helsingborg, Staffansbank, Barsebäck, Lomma Bay (Fig. 88)

Polyhalobe meioeuryhaline.

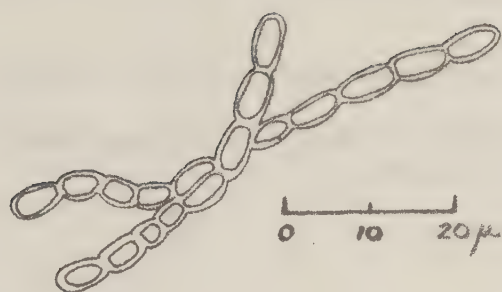


Fig. 86. *Nemalion multifidum*, sporophyte stage.

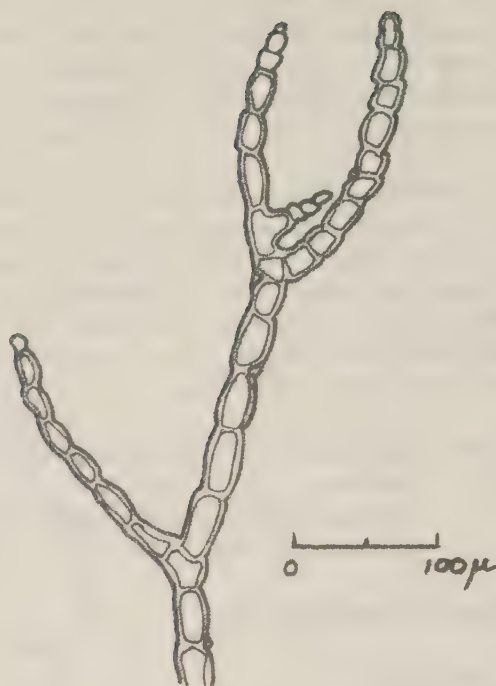


Fig. 87. *Trailliella intricata*.

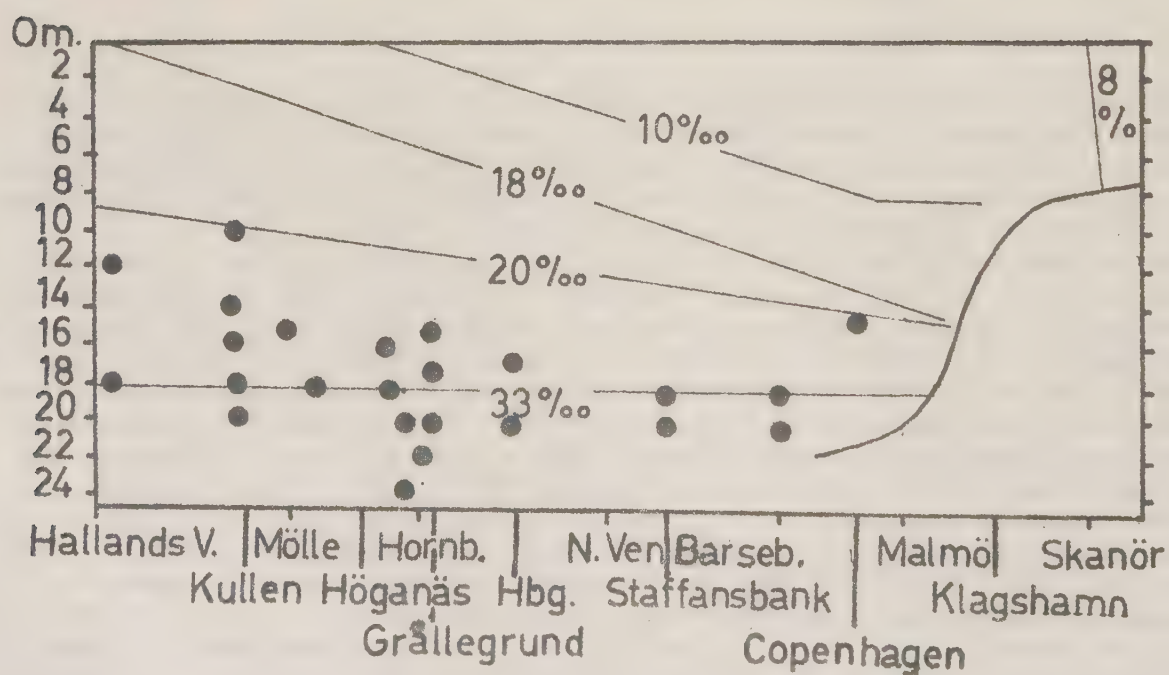


Fig. 88. The distribution of *Trailliella intricata* in relation to depth and salinity.

GIGARTINALESCruoriaceaeCruoria pellita (Lyngb.) Fries

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935).

Denmark: Kattegatt, Samsö, The Belts, Öresund.

This crust-forming species is most common in the north part of the area. In the south part only small crusts have been found and south of Klagshamn no finds have been made. It grows conspicuously at 5 - 25 m in depth on stones and shells. To a lesser extent *Cruoria* crusts can also be found on *Fucus serratus* and *Laminaria* hapters.

The crusts are 1 - 15 cm in diameter and often up to 0.4 - 0.6 mm thick. No sexual plants have been observed but specimens with tetrasporangia are frequently found from August to March.

Localities: Common in the north and central part; W. Malmö, Sjollen, W. Limhamn, W. Klagshamn.

Polyhalobe mesoeuryhaline.

Cruoriopsis gracilis (Kuck.) Batt.

Distribution Sweden: Bohuslän, Kristineberg, Kylin (1944).

Denmark: Little Belt.

Cruoriopsis gracilis is probably not uncommon in the north part of the Öresund from 5 - 20 m in depth on stones. It is often found together with *Cruoria pellita* and *Hildenbrandia prototypus*. It can often be of the same colour as the latter species but is easily separated by its greater thickness. It is also comparatively easy to remove from the substrate with, for instance, a nail.

The bright purple crusts are about 1 - 2 cm in diameter and 0.2 - 0.4 mm thick. The erect filaments are 4 - 6 μ thick and relatively short, 10 - 15 cells long. Tetrasporangia are found from June to October.

Localities: Off Hallands Väderö, Kullen, Hornbaek Bay, Grällegrund, off Helsingborg.

Polyhalobe meioeuryhaline.

Petrocelis hennedyi (Harv.) Batt.

Distribution Sweden: Bohuslän and N. Halland, Kylin (1944).

Denmark: All districts except Smålandshavet.

This species which is frequently found in the whole of Öresund has probably been overlooked along the Swedish west-coast south of Gothenburg. In the Öresund it is found from 0.75 - 15 - (20) m in depth on small and large stones and large shells. The species has not been found growing on other algae, e.g. *Laminaria* hapters, as stated by both Rosenvinge (1917) and Kylin (loc.cit.), except on old *Lithothamnion lenormandii* crusts.

Petrocelis hennedyi forms thin, "fleshy", light to dark red crusts, 1 - 6 - (7) cm in diameter. The cells in the erect filaments are 3 - 5.5 μ thick and 1 - 4 times as long. Intercalary tetrasporangia have been found in low numbers throughout the year. No sexual plants have been met with in the Öresund material.

Localities: Frequent in the whole area.

Polyhalobe mesoeuryhaline.

FurcellariaceaeFurcellaria fastigiata (L.) Lamour.

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935); Blekinge, Levring (1940); Småland and Gotland, Svedelius (1901); Öregrund, Waern (1952).

Denmark: All districts.

Furcellaria fastigiata is one of the main algal components of the sublittoral zone in the whole of Öresund. It is found at shaded and rather exposed localities from 2 - 27 m in depth on stones or shells. At Kullen the species is found from about 0.5 m below the 0-line. *Furcellaria fastigiata* is very tolerant to pollution and common even in the most polluted parts of the area.

There is a reduction of the size of *Furcellaria fastigiata* towards the south parts of the Öresund. The specimens growing near the upper limit of the sublittoral zone in the north part are 4 - 6 cm long and 1 mm thick, from 4 - 10 m in depth 10 - 15 cm long and below the halocline (about 10 - 12 m) 15 - 20 cm long and 1.5 - 2 mm thick. In the south part of the area, from 6 - 15 m in depth, the average length is 9 - 12 cm and the thickness 1 mm. There is also a marked change in the colour of the species from north to south. In the north and central part of the Öresund the specimens have the normal redviolet, almost black colour. In the southernmost part the species is light violet to almost light brown with often a greenish tint in the younger parts of the thalli. In the north part of the area *Furcellaria fastigiata* is more or less covered with different epiphytes, e.g. *Calolithamnion* sp., *Delesseria sanguinea*, *Epilithon membranaceum*, *Spermothamnion repens* and *Trailliella intricata*, in contrast to the south part of the area where *Furcellaria* plants are almost devoid of epiphytes. Sexual plants are found from December to April and plants with tetrasporangia are frequent from October to December.

Localities: Common in the whole area.

Polyhalobe pleioeuryhaline.

RhodophyllidaceaeCystoclonium purpureum (Huds.) Batt.

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935).

Denmark: All districts except the Baltic proper.

Kylin (loc.cit.) states, "längs der ganzen Westküste verbreitet, gemein mit Ausnahme der südlichsten Teile der Westküste" and Levring (loc.cit), "sie scheint nur spärlich vor zu kommen". According to the author's experience there does not seem to be any difference in the abundance of the species along the Swedish west-coast and in the north part of Öresund. *Cystoclonium purpureum* is common in the north part, frequent in the central and sparse in the south part. It is found from (8) - 10 - 25 m in depth growing on stones, larger shells and different algae.

The length of the fully developed thalli is 15 - 20 cm but specimens with a length of up to 30 cm have been observed in the north part of the area. In the south part the mean length is approximately 10 cm. Young specimens, 2 - 5 cm long, are found in March and the species reaches its fully development in July and August. Old specimens are found during autumn and as a rule also in January to February when they decay rapidly. The cystocarps begin to develop in May and are found until November.

Localities: Common in the north part; Staffansbank, Barsebäck, W. Saltholm, Sjollen, W. Malmö, W. Klagshamn.

Polyhalobe mesoeuryhaline.

PhyllophoraceaeAhnfeltia plicata (Huds.) Fries

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935); Blekinge, Levring (1940); Trosa archipelago (near Stockholm), Wallentinus (1969).

Denmark: All districts except Bornholm.

This species is common in the whole of Öresund except the southernmost part where it is frequent. At Hallands Väderö and Kullen it is found at exposed localities in a narrow belt from the 0-line to 0.5 m below. In the whole area single specimens can be found in abundance from 1 - 10 - (15) m in depth. The species grows on rocks and stones.

The specimens are about 5 - 10 cm high when they are fully developed. Below 10 m in depth they are reduced, 2 - 4 cm long, and consist of only a few branches. In the south part of the area the average length of the thalli is 4 - 5 cm. Nemathecia with monospores are found from November to May.

Localities: Common in the whole area except the southernmost part.

Polyhalobe pleioeuryhaline.

Ceratocolax hartzii Rosenv.

Distribution Sweden: Bohuslän, Saltkällefjorden, Levring (1935 b); Kullen, Levring (1935).

Denmark: All districts except Smålandshavet and the Baltic proper.

This parasitical red alga seems to be obligate to *Phyllophora brodiaei* and shows a remarkable periodical occurrence in the Öresund. Some years it is very common and up to 75 % of all examined specimens of *Phyllophora brodiaei* seem to be infected. Other years it is only found on the host in a few cases. The species is found in the whole area from 2 - 15 - (20) m in depth.

The size of the globular parasite seldom exceeds 2 - 3 mm in the Öresund while Rosenvinge (1931) mentions the size of 4 - 5 mm in Kattegatt. It is found throughout the year but is most frequent from November to April. Tetrasporangia in nemathecia have been observed from February to May.

Localities: Found in the whole area.

Polyhalobe mesoeuryhaline.

Phyllophora brodiaei (Turn.) Endl.

(*Phyllophora truncata* (Pallas) Newroth & Taylor)

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935); Blekinge, Levring (1940); Småland and Gotland, Svedelius (1901); Öregrund, Waern (1952).

Denmark: All districts.

Phyllophora brodiaei is very variable and one can find specimens that are similar to f. *concatenata* (Lyngb.) Aresch., f. *interrupta* (Grev.) Rosenv. and f. *ligulata* (Ag.) Sjöstedt. However, there are transitional stages between all these forms and they are according to the author's opinion only modifications.

Phyllophora brodiaei is, together with *Phyllophora membranifolia*, *Poly-siphonia nigrescens* and *Rhodomela confervoides*, the most wide-spread and most

tolerant to low salinity of the Scandinavian red algae. At the same time these species are good examples of the influence of decreasing salinity on the morphology and physiology of the algae. In the Öresund *Phyllophora brodiaei* is very common from 2 - 27 m in depth though it is found on the north side of Kullen from 0.5 m below the 0-line. It grows on stones and shells.

The length of the thalli varies from 6 - 25 cm but the average length is 10 - 14 cm. Nemathecia are mainly found from January to April but also in August to October.

Localities: Common in the whole area.

Polyhalobe pleioeuryhaline.

Phyllophora crispa (Huds.) Dixon

(*Phyllophora rubens* (L.) Grev.)

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935).

Denmark: Kattegatt, Samsö, The Belts, W. Baltic.

This species is very sparsely found along the Swedish west-coast. Levring (loc.cit) states, "von dieser Art habe ich nur einige wenige Exemplare erhalten". Rosenvinge (1931) reports one find from the Öresund but it was obviously a drifting specimen ("washed ashore"). The author has only found the species in attached state at two localities around Gilleleje flack at 10 m in depth in December.

Localities: Gilleleje flack, N. Tidsvildeleje.

Polyhalobe meioeuryhaline.

Phyllophora membranifolia (Good. et Woodw.) J. Ag.

(*Phyllophora pseudoceranoides* (Gmel.) Newroth & Taylor)

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935); Blekinge, Levring (1940); Småland, Svedelius (1901); Gotland, Krok (1869); Öregrund, Waern (1952).

Denmark: All districts.

This species is common in the whole of Öresund from 2 - 27 m in depth on stones and shells. On the north side of Kullen it is found from 0.75 m below the 0-line. In the north part of the area at depths of 10 - 13 m 50 % of the algal biomass consists of *Phyllophora membranifolia*.

The best developed specimens are found between 10 - 20 m in depth where the length of the thalli is 10 - 12 cm. In the upper part of the sublittoral zone the length is only 5 - 10 cm. The nemathecia are found from August to December and fertile specimens from February to May.

Localities: Common in the whole area.

Polyhalobe pleioeuryhaline.

Gigartinaceae

Chondrus crispus (L.) Stackh.

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935).

Denmark: All districts except Bornholm.

Chondrus crispus is very variable in morphology and Kylin (loc.cit) mentions 5 different forms: f. *abbreviata* Kjellm., f. *aequalis* (Turn.) Lyngb., f. *densa* Rosenv., f. *polychotoma* Kjellm. and f. "typica" Rosenv. The author has observed transitional stages between these forms which are probably only modifications.

The species is common in the north part of the area and is found in low-lying rock-pools up to 6 m above the 0-line and down to 27 m in depth. In the central part the species is frequently found from 6 - 27 m in depth. South of the line Malmö - Copenhagen only a few finds of rather reduced specimens at 6 - 8 m in depth have been made.

The specimens growing in the littoral zone and the upper part of the sublittoral zone are small and compact, 2 - 5 cm long. In the lower part of the sublittoral zone larger forms up to 10 - 12 cm long are found. Fertile specimens have been met with from March to November. Tetraspore-bearing plants are found during the whole year but mainly from December to April.

Localities: Common in the north part; Knäshaken, Staffansbank, W. Barsebäck, Salt-holm flack, Sjollen, W. Malmö, W. Klagshamn, Bredgrund.

Polyhalobe mesoeuryhaline.

CRYPTONEMIALES

Squamariaceae

Rhodophysema elegans (Crouan frat. ex J. Ag.) Dixon

(*Rhododermis elegans* Crouan)

Distribution Sweden: Bohuslän, Koster, Kristineberg, von Wachenfeldt (unpubl.); Hallands Väderö, Sjöstedt (1927); Kullen, Levring (1935).

Denmark: Kattegatt, Samsö, Little Belt.

The species is previously recorded only from Hallands Väderö and Kullen. Sjöstedt (loc.cit.) mentions a find of *Rhododermis parasitica* which seems to be conspecific with *Rhodophysema elegans*.

The author has found *Rhodophysema elegans* at several localities along the whole Swedish west-coast as well as in the north part of the Öresund. In the Öresund it is frequently found from 0.1 - 27 m in depth on many different hosts. Most of the finds are on *Chondrus crispus*, *Dilsea carnosa*, *Furcellaria fastigiata*, *Phyllophora brodiaei*, *Phyllophora membranifolia* and *Rhodymenia palmata* and to a lesser extent *Callithamnion* sp., *Chaetomorpha melagonium* and *Cladophora rupestris*.

The discs are 0.5 - 1.5 mm in diameter and the cells 5 - 7 x (5) - 6 - 9 μ . The species is found throughout the year. No sexual plants have been observed and plants with tetrasporangia are sparse from November to March.

Localities: Off Hallands Väderö, Kullen, Mölle, Vattenmöllan, Gilleleje flack, Ellekilde hage, Hornbaek Bay, Grållegrund, off Råå.

Polyhalobe mesoeuryhaline.

Rhodophysema georgii Batt.

Distribution Sweden: Bohuslän, Koster, Väderöarna, Kristineberg, Kylin (1944); Kullen, Levring (1935).

Denmark: N. Kattegatt, Samsö, The Belts.

Levring (loc.cit.) recorded the species a few times on old *Zostera* leaves

from Kullen. The author has not been able to find the species in the Öresund area.

Locality: -

Polyhalobe meioeuryhaline.

Hildenbrandiaceae

Hildenbrandia prototypus Nardo

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935); Blekinge, Levring (1940); Öregrund, Waern (1952).

Denmark: All districts.

The species is common in the whole area at shaded and exposed localities from 3 - 4 m above the 0-line down to 25 - 30 m in depth growing on stones and shells.

Localities: Common in the whole area.

Polyhalobe pleioeuryhaline.

Corallinaceae

Corallina officinalis L.

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935); N. Helsingborg, Ven, Suneson (1943).

Denmark: Kattegatt, Samsö, The Belts.

Both the vertical and the horizontal distribution of *Corallina officinalis* along the Swedish west-coast is a very good example of the influence of the salinity on certain algae. Kylin (loc.cit.) stated, "an der bohuslänschen Küste assoziationsbildend - - - in einer Tiefe von 0.5 - 2 m, darunter bis in einer Tiefe von etwa 20 m in mehr verstreuten Individuen". Levring (loc.cit.) mentions the species from Kullen, "einige wenige Exemplare in der Sublitoralregion angetroffen". Suneson (loc.cit.) has recorded single specimens near Helsingborg and Ven.

The species is frequently found in the north part of the area from Hallands Väderö to Höganäs at 15 - 25 m in depth. It may even be common at some localities at 20 - 25 m in depth and one could talk of a *Corallina* association. South of Höganäs down to Helsingborg - Helsingör *Corallina officinalis* is frequent but always in very low numbers at the same depths. In the northernmost part *Corallina officinalis* grows most frequently on stones or crust-forming Lithothamnion species and more rarely on other algae. South of Kullen the species grows on different algae such as *Laminaria* sp., *Odonthalia dentata*, *Phyllophora* sp. and on shells. The south border of the species seems to coincide with the 25 ‰ isohaline and the salinity at the *Corallina* localities does not go below 20 ‰.

The thalli of specimens from the north part of the area are fully developed, 3 - 5 cm high and about 0.5 - 1 mm thick in the basal parts. In a very few cases some reduced specimens, 1 - 2 cm high and 0.3 - 0.5 mm thick, have been found near the halocline at 12 - 15 m in depth. Reduced specimens are also found now and then north of Ven and at Staffansbank at 20 - 25 m in depth. No sexual plants have been noticed in the Öresund but plants with tetrasporangia are sparsely found in the north part of the area from February to September.

Localities: Off Hallands Väderö, Kullen, Vattenmöllan, Gilleleje flack, Ellekilde

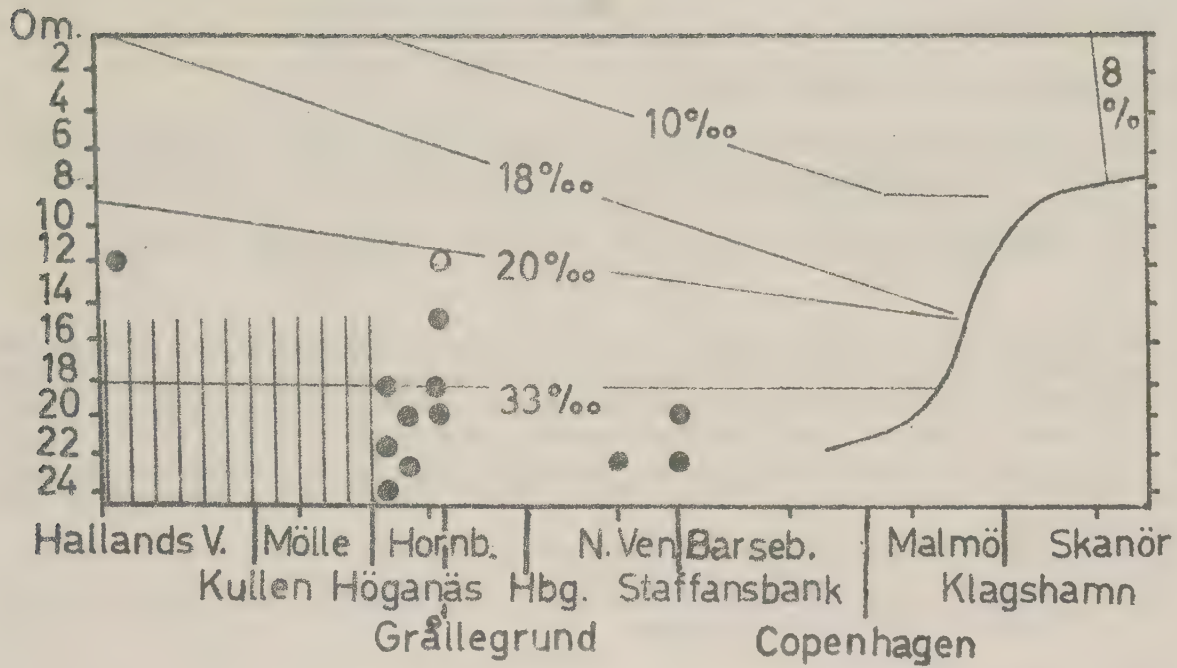


Fig. 89. The distribution of *Corallina officinalis* in relation to depth and salinity.

||||| frequent ○ reduced specimens

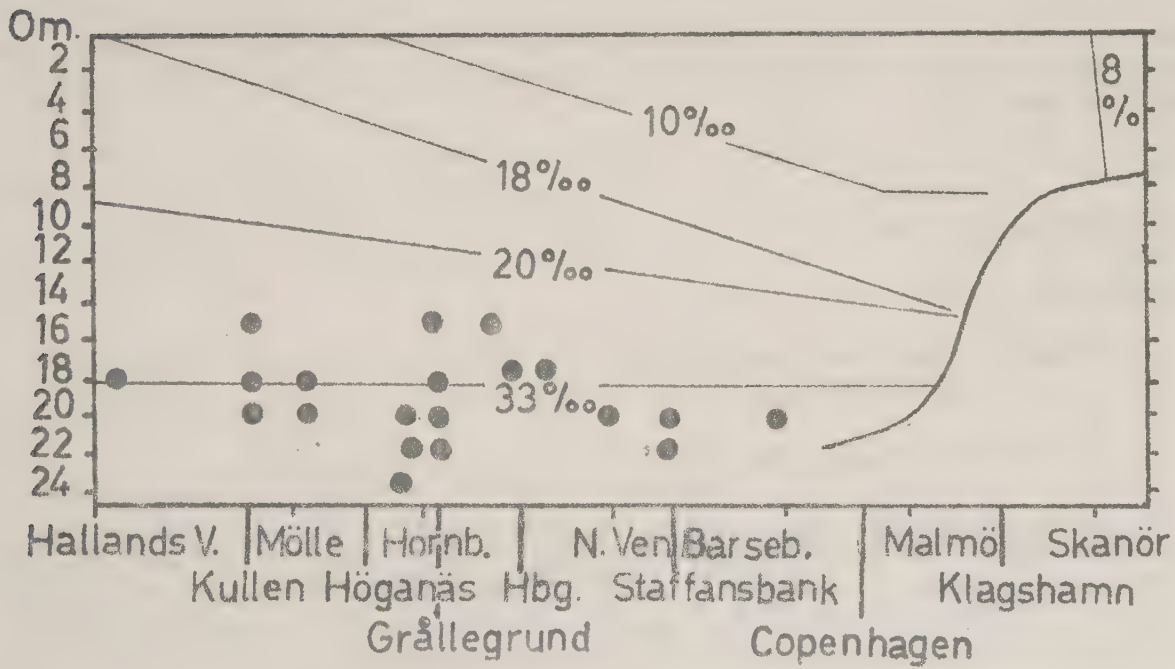


Fig. 90. The distribution of *Dilsea carnosa* in relation to depth and salinity.

hage, Hornbaek Bay, Grålleggrund, N. Ven, Staffansbank. (Fig. 89)

Polyhalobe meioeuryhaline.

Epilithon membranaceum (Esper) Heydr.

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935); south Öresund, e.g. Flintrännan, Sjollen, Suneson (1943).

Denmark: Kattegatt, Samsö, The Belts, Smålandshavet, Öresund, W. Baltic.

The species is a common epiphyte on *Furcellaria fastigiata* and more sparsely on *Chondrus crispus*, *Phyllophora* sp. and *Rhodomenia palmata*. In the north part of the area more than 50 % of the *Furcellaria* specimens bear the epiphyte from 3 - 25 m in depth. South of the line Helsingborg - Helsingör the species is less abundant and south of Landskrona sparse. South of Limhamn the author has sought in vain for *Epilithon membranaceum*, though *Furcellaria fastigiata* is common in this part of the area.

Localities: Common in the north part; Knähaken, Staffansbank, Barsebäck, Saltholm flack, W. Malmö, W. Limhamn.

Polyhalobe mesoeuryhaline.

Lithophyllum litorale Suneson

Distribution Sweden: Bohuslän, Väderöarna, Kristineberg and Hallands Väderö, Suneson (1943); Kullen, Levring (1935).

Denmark: N. and S. Kattegatt, Samsö.

This species which is rare in Kattegatt has been recorded once from Hallands Väderö by Suneson (loc.cit.) and by Levring (loc.cit.) at Kullen as *Lithophyllum macrocarpum* (Rosan.) Fosl. The author has not succeeded in finding the species and most probably both Suneson's and Levring's observations have been made on drifting specimens of *Fucus* sp.

Locality: -

Polyhalobe oligoeuryhaline.

Lithophyllum orbiculatum (Fosl.) Fosl.

Distribution Sweden: Bohuslän, Kristineberg and Halland, Gottskär, Varberg and Hallands Väderö, N. Helsingborg, Ven, Suneson (1943).

Denmark: Kattegatt and Öresund (in all 6 localities).

The species which was described on material from the Swedish west-coast seems to be very rare in the Öresund. Rosenvinge (1917) found it at one locality in the Sound and Suneson (loc.cit.) recorded it from three localities. The author has met with *Lithophyllum orbiculatum* on two occasions at 15 - 20 m in depth on pebbles. In both cases the crusts were 2 - 3 cm in diameter.

Localities: Gilleleje flack, Staffansbank.

Polyhalobe oligoeuryhaline.

Lithothamnion granii Fosl.

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Öresund, e.g. Staffansbank, Suneson (1943).

Denmark: Kattegatt, Samsö, The Belts, Öresund.

Lithothamnion granii is frequently found in the north and central part of the Öresund. It grows from 10 - 25 m in depth mainly on pebbles and shells. At one locality north of Ven at 15 - 22 m in depth with upwelling saline water the species is very conspicuous and is almost the only species found there. The crusts are 3 - 6 cm in diameter and the wartlike processes 1 - 3 mm high. At the southernmost localities they never exceed 1 mm in height.

Localities: Frequent south as far as the line Landskrona - Ven - Sletten.

Polyhalobe meioeuryhaline.

Lithothamnion lenormandii (Aresch. in J. Ag.) Fosl.

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935); Ven, Saltholm flack, Suneson (1943).

Denmark: All districts except W. Baltic.

Lithothamnion lenormandii is together with *Lithothamnion polymorphum* the most common Corallinaceae in the Öresund. In the north part of the area the species is commonly found at shaded and exposed localities from the 0-line. At more sheltered and sunny localities the upper limit is found at 0.5 - 1 m in depth. It has been observed down to 27 m in depth. The species is found on stones but is also conspicuous on pebbles and mollusc shells such as *Cyprina*, *Modiolus*, *Mya* and *Mytilus*. The crusts are often spread over large areas on the bottom. In the central part of the Öresund the species is still conspicuous but with the upper limit at about 5 m in depth. South of Malmö the species is sparse and only found as small crusts, 1 - 3 cm in diameter.

At localities where *Lithothamnion lenormandii* grows in the littoral zone it is often killed during the low water in February to March, either by low temperature or by drying or a combination of these two parameters. At localities below 15 m in depth in the north part of the area, *Lithothamnion lenormandii* has to compete for space with *Lithothamnion polymorphum*. The author has often found *Lithothamnion lenormandii* crusts overgrown with *Lithothamnion polymorphum*.

The apparently closely related species *Lithothamnion laeve* has been recorded from the Öresund by Rosenvinge (1917), but the author has not found the species in the Öresund area.

Localities: Common in the north and central part; W. Limhamn, W. Klagshamn.

Polyhalobe mesoeuryhaline.

Lithothamnion polymorphum (L.) Aresch. in J. Ag.

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935); Ven, Suneson (1943).

Denmark: All districts except Smålandshavet, W. Baltic, Bornholm.

Lithothamnion polymorphum is common in the north part of the area from (10) - 15 - 25 m in depth where it covers vast areas of rocks or larger stones especially at Kullen and Gilleleje flack. At these two localities the species is one of the dominating algae. In the northernmost part the species is met with already from

0.5 m in depth as in Bohuslän. At Kullen the species is frequently found from 1 m in depth as small patches on *Laminaria* hapters and other large algae. These have been referred to as *Lithothamnion laevigatum* by Levring (loc.cit.). South of Kullen - Gilleleje the species is not so dominating and south of Helsingborg - Helsingör only a few finds, on pebbles, have been made.

Localities: Littoral zone: Hovs Hallar, Hallands Väderö.

Sublittoral zone: Hovs Hallar, off Hallands Väderö, Kullen, Vattenmöllan, Gilleleje flack, Hornbaek Bay, Grälleggrund, W. Helsingborg, N. Ven, Staffansbank, N. Barsebäck.

Polyhalobe meioeuryhaline.

Lithothamnion sonderi Hauck

Distribution Sweden: Bohuslän and N. Halland, Kylin (1944); Hallands Väderö, Sjöstedt (1927).

Denmark: N. and E. Kattegatt, Samsö, Great Belt, Smålandshavet.

* This species is found frequently but in very low numbers in the north part of the Öresund from (7) - 10 - 20 m in depth. Almost all the finds have been made on old *Mytilus* shells. The reason why the species is only found on *Mytilus* shells and not on stones as in other areas may be that it has difficulty to compete with more conspicuous species such as *Lithothamnion lenormandii* and *Lithothamnion polymorphum*.

Localities: Kullen, Mölle, Vattenmöllan, Grälleggrund.

Polyhalobe meioeuryhaline.

Melobesia lejolisii Rosan.

Distribution Sweden: Bohuslän, Väderöarna, Kylin (1907); Kristineberg, Suneson (1943); Halland, Varberg, Hylmö (in herbarium, Botanical Museum, Lund); Kullen, Levring (1935).

Denmark: N. and middle Kattegatt, Samsö, The Belts, Smålandshavet.

This species which according to the literature is found on old *Zostera* leaves, has been recorded at Kullen by Levring (loc.cit.), most probably on drifting specimens. The author has never found *Melobesia lejolisii* in the Öresund.

Locality: -

Polyhalobe oligoeuryhaline.

Melobesia limitata (Fosl.) Rosenv.

Distribution Sweden: Bohuslän, Koster, Väderöarna, Kylin (1907); Kristineberg, Halland: Gottskär, Hallands Väderö, Suneson (1943).

Denmark: N. Kattegatt, Samsö.

The species was recorded by Levring (1935) from Kullen but according to Suneson (loc.cit.) it proved to be *Epilithon membranaceum*. The author has not seen the species in the Öresund area.

Locality: -

Polyhalobe oligoeuryhaline.

Melobesia minutula Fosl.

Distribution Sweden: Bohuslän, Väderöarna, Kristineberg and Halland, Varberg, Suneson (1943); Kullen, Levring (1935).

Denmark: N. Kattegatt.

This species has been found on three occasions, from 15 - 25 m in depth, on *Chondrus crispus*, *Delesseria sanguinea* and *Rhodymenia palmata*. In the middle of the disc the cells were quadrangular, 7 - 9 μ broad. The cells near the margin of the disc were 6 - 7 μ broad.

Localities: Kullen, Vattenmöllan, W. Barsebäck.

Polyhalobe oligoeuryhaline.

Dumontiaceae

Dilsea carnosa (Schmidel) Kuntze

(*Dilsea edulis* Stackh.)

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935).

Denmark: N. and E. Kattegatt, Öresund.

This species, frequently distributed in very low numbers in the north and central part of the Öresund, grows from 15 - 25 m in depth, on stones and shells, often on soft bottoms. The species has its south border south of Ven. The plants are as a rule 10 - 15 cm long in the north part of the Öresund and old specimens, 30 - 40 cm in length, are frequently found. No sexual plants have been observed. Tetrasporangia are found from December to March.

Localities: Off Hallands Väderö, Kullen, Vattenmöllan, Ellekilde hage, Hornbaek Bay, Grälleggrund, off Hittarp, Helsingborg, Knähaken, N. Ven, Staf-fansbank, Pinhättan. (Fig. 90)

Polyhalobe oligoeuryhaline.

Dumontia incrassata (O. F. Müll.) Lamour.

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935).

Denmark: All districts except Baltic Möen.

According to Levring (loc.cit.) *Dumontia incrassata* was "ziemlich selten" at Kullen. Today the species can be said to be common in the whole area. It grows singly in low-lying rock-pools up to 5 m above the 0-line and from 0.2 - 0.3 m below the 0-line down to 1 - 1.5 m where it often forms a dense belt on stones. Single specimens are also found from 4 - 12 m in depth on pebbles and shells. Growth seems to be promoted by polluted water. Specimens growing near Copenhagen harbour are often twice as big as specimens growing in the same salinity but in more clean water.

The growth of the *Dumontia incrassata* belt begins in the later part of December and already in the middle of January the specimens are 10 - 15 cm high. This early *Dumontia* vegetation is often killed by frost or low water in February and March. Growth starts again in late March and the *Dumontia* belt is fully developed in the end of April and May. At the beginning of June most specimens begin to decay and in July no trace of the species can be found in the littoral and the first metres of the sublittoral zone. Kylin (loc.cit.) states that the

species can be found in the autumn along the west-coast, but this is not the case in the Öresund.

The fully developed thalli are 15 - 22 cm long and 1 - 2 mm in breadth. In the south part of the area the specimens are 6 - 12 cm long and 1 mm thick. The specimens in the sublittoral zone which grow singly especially from 4 - 12 m in depth, have a much slower development and reach full size in July. These specimens usually are 10 - 12 cm long but a dark red one, 40 cm long and 4 mm thick, was once found at a depth of 12 m in the middle of July. In August no specimens have been observed. During spring the colour of *Dumontia incrassata* is dark red; in the end of May the species turns light red to red-yellow and sometimes straw-coloured. Specimens with gonimoblasts seem to be sparse. Tetrasporangia are frequently found from April to June.

Localities: Common in the whole area.

Polyhalobe pleioeuryhaline.

Polyideaceae

Polyides rotundus (Huds.) Grev.

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935); Blekinge, Levring (1940); Gotland, Waern (1952).

Denmark: All districts except Smålandshavet and Bornholm.

Polyides rotundus is frequently found in low numbers at Kullen from (1) - 5 - 25 m in depth and in the rest of the area from 5 - 25 m in depth. In the south part of the area very few specimens are found, though it is rare but widely distributed in the Baltic. It grows on stones and shells together with *Furcellaria fastigiata*.

The thalli are 5 - 10 cm long and about 1 mm broad. Fertile specimens with carpogonia or spermatangia are found from September to December in the north part of the area down to Helsingborg. The material from the south part of the area is too sparse to make any certain statement of the reproductive conditions. The life-cycle of *Polyides rotundus* ought to be studied since Kylin (loc.cit.), like the author, did not find any tetraspore-bearing specimens of the species. Rosenvinge (1917) only found a few tetrasporic specimens in the north of Kattegatt.

Localities: Found in low numbers at almost all dredging stations.

Polyhalobe pleioeuryhaline.

Kallymeniaceae

Euthora cristata (C. Ag.) J. Ag.

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Hallands Väderö, Suneson (1941); Kullen, Levring (1935).

Denmark: E. Kattegatt.

The species was found on one occasion by Levring (loc.cit.) in material from 20 m in depth. The author has only once come across some specimens of *Euthora cristata* at the north side of Kullen from 18 - 20 m in depth. The specimens were growing on *Odonthalia dentata* and *Ptilota plumosa* and were of normal size for the Swedish west-coast, about 2 cm high, but sterile. Jaasund (1965) gives the measurement of 5 - 12 cm from north Norway.

Locality: Kullen.

Polyhalobe oligoeuryhaline.

ChoreocolacaceaeHarveyella mirabilis (Reinsch) Reinke

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935); Blekinge, Levring (1940); Gotland, Svedelius (1901).

Denmark: All districts except Smålandshavet.

This parasitic alga is found frequently in the whole Öresund area from 5 - 20 m in depth. The species is almost always found on *Rhodomela confervoides* but on some occasions it has been growing on *Rhodomela virgata*.

Harveyella mirabilis is more common and larger in the north part of the area, where the diameter of the cushions slightly exceeds 1 mm. In the south part it never exceeds 0.5 mm in diameter. The species is found from October to May and is lacking during the summer months. On some occasions the author has found sexual plants with carpospores from November to February and during the rest of the year plants with tetrasporangia.

Localities: Off Hallands Väderö, Kullen, Vattenmöllan, Gilleleje flack, Hornbaek Bay, off Helsingborg, off Ålabodarna, W. Barsebäck, W. Limhamn, Bredgrund.

Polyhalobe pleioeuryhaline.

RHODYMENIALESRhodymeniaceaeRhodymenia palmata (L.) Grev.

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935).

Denmark: Kattegatt, Samsö, The Belts, Öresund.

Rhodymenia palmata is abundant in the north part of the Öresund and in the central part south to Landskrona. It is frequently found south down to Limhamn. Rosenvinge (1931) mentions some finds from the western part of the Baltic near Möens klint but these finds are apparently loose-lying, drifting specimens. The species grows from 10 - 25 m in depth on stones and larger shells, e.g. *Cyprina islandica*, and on the stipes of *Laminaria digitata*.

Fully developed specimens are 15 - 20 - (25) cm long. The average age of the specimens seems to be 2 - 3 years. Plants with tetrasporangia are met with from November to March.

Localities: Abundant in the north part; Knäshaken, Staffansbank, W. Barsebäck, N. Saltholm, W. Lomma, Kalkgrundet.

Polyhalobe meioeuryhaline.

CERAMIALESCeramiaceaeAntithamnion boreale (Gobi) Kjellm.

Distribution Sweden: Bohuslän, Lysekil, Levring (1933); Halland, Varberg, Morup, Kylin (1907); Hallands Väderö, Sjöstedt (1927); Kullen, Levring (1935); Ven, Waern (1965 a).

Denmark: Kattegatt, Samsö, The Belts, Öresund, the Baltic proper.

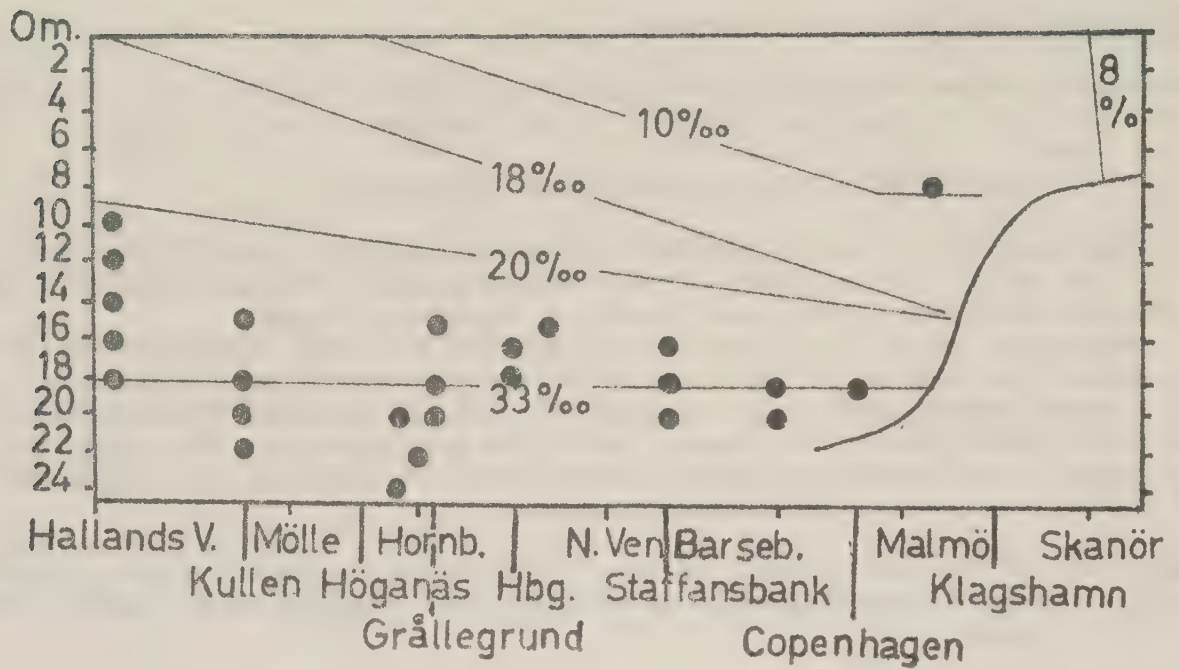


Fig. 91. The distribution of *Antithamnion boreale* in relation to depth and salinity.

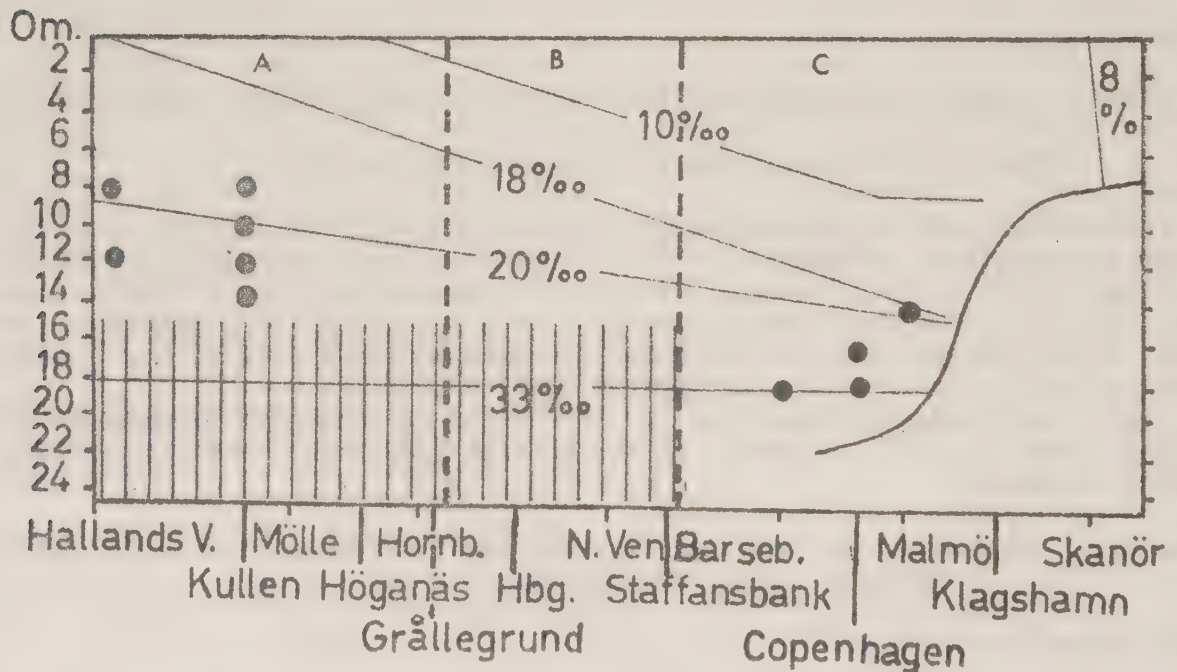


Fig. 92. The distribution of *Antithamnion plumula* in relation to depth and salinity.

||||| abundant

- A specimens with sexual organs
- B specimens with tetrasporangia
- C specimens without reproductive organs

The distribution of this species is poorly known along the Swedish west-coast. It is frequently found in the Öresund though only in low numbers. It grows from (8) - 10 - 25 m in depth on different algae, such as *Furcellaria fastigiata*, *Odonthalia dentata* and *Phycodrys rubens*. The specimens are 1 - 3 cm long and found throughout the year. Neither sexual organs nor tetraspores have been observed in the material from the Öresund.

Localities: Off Hallands Väderö, off Kullen, Hornbaek Bay, Grållegrund, W. Helsingborg, Knähaken, Staffansbank, W. Barsebäck, Lomma Bay, W. Limhamn. (Fig. 91)

Polyhalobe pleioeuryhaline.

Antithamnion plumula (Ellis) Thur. in Le Jol.

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935); Ven, Waern (1965 a).

Denmark: Kattegatt, Samsö, The Belts, Öresund (one find).

Antithamnion plumula is according to Kylin (loc.cit.) "längs der ganzen Westküste verbreitet, spärlich (Halland) bis ziemlich gemein (Bohuslän)" and Levring (loc.cit.) at Kullen "selten".

In the Öresund *Antithamnion plumula* has a very interesting distribution. It is found in the north and central part from (8) - 15 - 25 - (27) m in depth. In the northernmost part, Hallands Väderö - Kullen, the species is found frequently in low numbers from 8 - 15 m in depth and abundantly down to 27 m in depth. At Kullen it is very common from 20 - 25 m in depth on *Ptilota plumosa*. South to Landskrona it is found abundantly from 15 - 25 m in depth. South of there down to west of Malmö single specimens are found now and then. The species grows on shells and larger algae, e.g. *Chaetomorpha melagonium*, *Desmarestia aculeata*, *Furcellaria fastigiata*, *Odonthalia dentata* and *Ptilota plumosa*.

The specimens usually are 1.5 - 3 cm long but in the north part from 8 - 15 m in depth 0.5 - 1 cm long and south of Landskrona only 0.2 - 0.5 cm long. The species is found throughout the year. Growth begins in March, fully developed specimens being found from July to October. Plants with cystocarps are found south to Hornbaek - Grållegrund below 15 m in depth from May to September and plants with tetrasporangia south to Landskrona from April to October. South of Landskrona no reproductive organs have been found. (Fig. 92)

Localities: Off Hallands Väderö, Kullen, Vattenmöllan, Gilleleje, Ellekilde hage, Hornbaek Bay, Grållegrund, W. Helsingborg, Knähaken, Staffansbank, W. Barsebäck, Lomma Bay, W. Malmö. (Fig. 92)

Polyhalobe meioeuryhaline.

Callithamnion bipinnatum Crouan

Distribution Sweden: Bohuslän, Kristineberg, Kylin (1933 a); Hållö, Suneson (1939 b).

Denmark: E. Kattegatt (one find).

Some specimens of *Callithamnion* were dredged at Grållegrund from 17 - 20 m in depth in August 1965. The plants were 1.5 - 2 cm long and agreed with the description of *Callithamnion bipinnatum*. All specimens possessed the typical unicellular branchlets depicted by Levring (1937). Both tetrasporic and sexual plants were found.

Locality: Grållegrund.

Polyhalobe oligoeuryhaline.

Callithamnion corymbosum (Sm.) Lyngb.

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935).

Denmark: Kattegatt, Samsö, The Belts, Smålandshavet, Öresund, W. Baltic.

Callithamnion corymbosum has an irregular distribution in the north of Öresund. The frequency of finds varies widely from year to year. Some years it is found sparsely down to Lomma Bay and other years very few or no finds at all are made in the entire area. The species is found from (2) - 10 - 25 m in depth growing on *Desmarestia aculeata*, *Furcellaria fastigiata*, *Odonthalia dentata* and *Polysiphonia nigrescens*.

The length of the plants varies from 2 cm in the north part to 0.5 cm in Lomma Bay. The species has been found from April to November. Plants with spermatangia and carpogonia or cystocarps have been observed south to Mölle (Fig. 93) from June to September. In the material found between Mölle and Grållegrund only tetrasporangia have been found from June to November, and south of Grållegrund no reproductive organs have been met with, though Rosenvinge(1923-24) mentions a find of a plant with carpogonia near Ven.

Localities: Off Hallands Väderö, Kullen, Vattenmöllan, Gilleleje flack, Grållegrund, Staffansbank, Lomma Bay. (Fig. 93)

Polyhalobe meioeuryhaline.

Callithamnion furcellariae J. Ag.

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935); Blekinge, Levring (1940).

Denmark: All districts except Smålandshavet.

The species is found sparsely in the north and central part of the Öresund area from 10 - 20 m in depth growing on *Furcellaria fastigiata*, *Polyides rotundus*, *Polysiphonia elongata*, *Polysiphonia nigrescens* and *Rhodomela confervoides*. According to Rosenvinge(1923-24) this species, in contrast to most other red algae, is somewhat better developed in low salinity than in high.

The length of the thalli varies from 1.5 - 2.5 - (3) cm. Specimens are found from February to November (-December). In the collected material of *Callithamnion furcellariae* both spermatangia, carpogonia, tetrasporangia and in a few cases bisporangia have been observed from May to September.

Localities: Off Hallands Väderö, Kullen, Hornbaek Bay, Grållegrund, Staffansbank, Lomma Bay.

Polyhalobe pleioeuryhaline.

Callithamnion hookeri (Dillw.) S. F. Gray

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935).

Denmark: Kattegatt, Samsö, The Belts, Öresund, W. Baltic.

The species is sparsely found in the north and central part of the Öresund. At Hallands Väderö and Kullen it is found from (0.5) - 1 - 25 m in depth and south of Kullen from 10 - 25 m in depth. The southernmost specimens have been found near Ven on Staffansbank. It grows mainly epiphytically on *Furcellaria fastigiata*, *Phyllophora brodiaei* and *Polysiphonia nigrescens* but in a few cases also on stones.

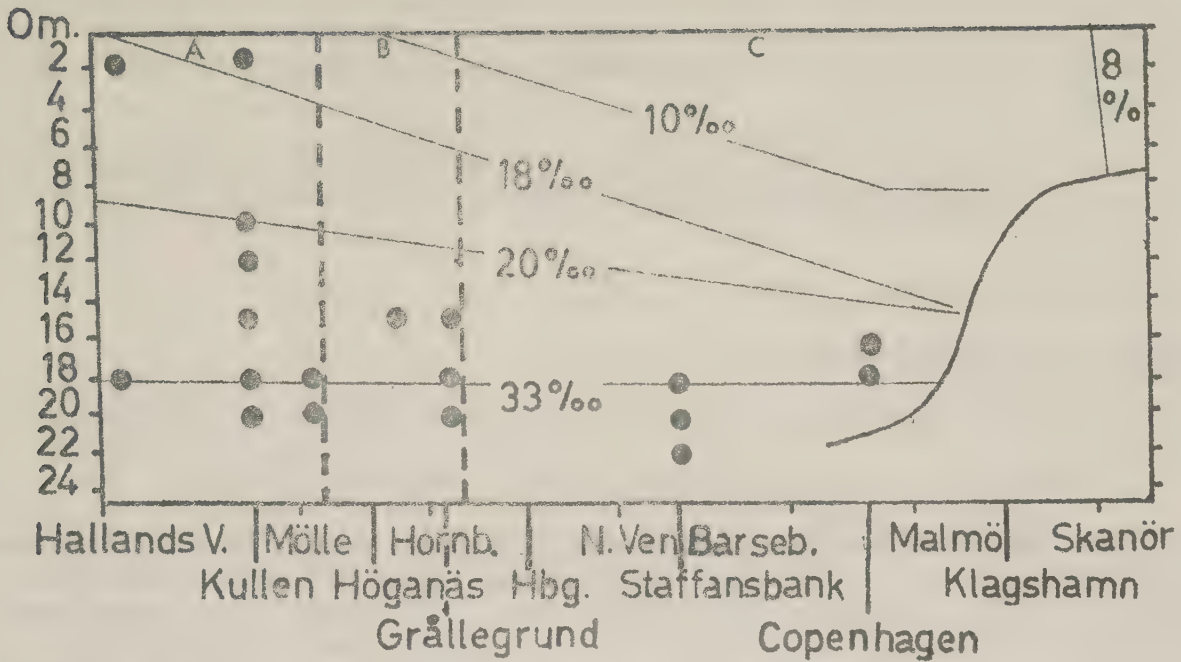


Fig. 93. The distribution of *Callithamnion corymbosum* in relation to depth and salinity.

- A specimens with sexual organs
- B specimens with tetrasporangia
- C specimens without reproductive organs

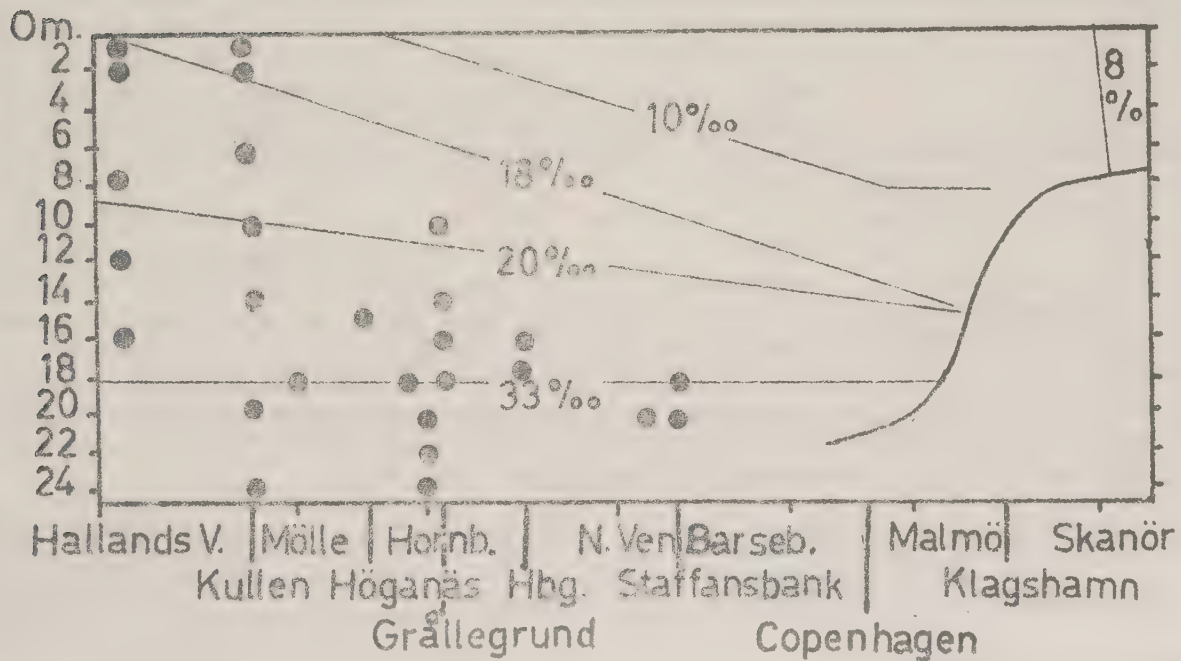


Fig. 94. The distribution of *Callithamnion hookeri* in relation to depth and salinity.

The length of the plants in the northernmost part is 1 - 4 cm, south of Kullen 1 - 2 cm and near Ven only 2 - 3 mm. The species is found from February to November. In the north part tetrasporangia and paraspores are found in low numbers from April to October. South of Grållegrund no reproductive organs have been observed.

Localities: Off Hallands Väderö, off Kullen, Vattenmöllan, Gilleleje flack, Ellekilde hage, Hornbaek Bay, Grållegrund, W. Helsingborg, Ven, Staffansbank. (Fig. 94)

Polyhalobe meioeuryhaline.

Callithamnion tetragonum (With.) S. F. Gray

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935).

Denmark: N. and E. Kattegatt, Samsö, Great Belt, Öresund.

Kylin (1907) reported *Callithamnion brachiatum* (Bonnem.) Harv., *Callithamnion fruticulosum* J. Ag., *Callithamnion spiniferum* Kylin and *Callithamnion tetragonum* (With.) C. Ag. from the Swedish west-coast. Later Kylin (1944) considered these four species to be conspecific and he transferred them to *Callithamnion fruticulosum* J. Ag. and considered *Callithamnion tetragonum* to be another species growing in i.a. Great Britain. Rosenvinge (1923-24) was of the opinion that the specimens from Kattegatt could be interpreted as *Callithamnion tetragonum* (With.) C. Ag. var. *fruticulosum* J. Ag. There are in the Agardh herbarium specimens from Kullen determined by J. Ag. as *Callithamnion fruticulosum*. Whether *Callithamnion fruticulosum* J. Ag. (*Phlebothamnion fruticulosum* Kütz.) and *Callithamnion tetragonum* (With.) S. F. Gray really are conspecific is not quite clear and ought to be studied.

Callithamnion tetragonum is easily distinguished from all other *Callithamnion* species found along the Swedish coast by its acuminate end-cells. The species is without doubt the most abundant *Callithamnion* species in the Öresund. At shaded localities at Kullen and Hallands Väderö the species is found from 0.5 m below the 0-line down to 20 m in depth, south of Kullen to Malmö from 5 - 8 m down to 20 - 25 m in depth. *Callithamnion tetragonum* grows on stones but more frequently on *Desmarestia aculeata*, *Furcellaria fastigiata*, *Phyllophora brodiaei*, *Phyllophora membranifolia* and *Polysiphonia* sp.

In the northernmost part of the area from 0.5 - 10 m in depth the length of the thalli is 5 - 6 cm and below 10 m, 3 - 5 cm. South of Kullen the length is 1.5 - 3 cm. *Callithamnion tetragonum* is found throughout the year with young stages in February and March and fully developed specimens from June. Carpegonia, spermatangia and cystocarps have been found north of Höganäs from June to September. Tetrasporic plants are found in the area south to the line Helsingborg - Helsingör. South of this line only specimens without reproductive organs have been found. In many cases both cystocarps and tetrasporangia have been found on the same specimen. This has also been observed by Rosenvinge (loc.cit.).

Localities: Off Hallands Väderö, Kullen, Gilleleje flack, Vattenmöllan, Ellekilde hage, Hornbaek Bay, Grållegrund, off Hittarp, W. Helsingborg, N. Ven, Staffansbank, Barsebäck, Saltholm flack.

Polyhalobe meioeuryhaline.

Ceramium

Dixon (1960) has summed up the present situation concerning the genus *Ceramium* in the following way: "at the present time the taxonomy of the genus *Ceramium* is in a stage of chaos. This is the result of the failure of phycologists to refer back, at all times, to original authentic material and the

failure to recognize and interpret seasonal and environmental modifications of the external form of the thallus". Still very little information is available on the cytology of this genus. This complex ought to be reviewed by means of culture studies and cytological methods. Opinions on Swedish *Ceramium* have previously been expressed by i.a. Sjöstedt (1928 b), Kylin (1944) and Waern (1952). Among the species and forms published by different authors from Sweden the author is bound to consider many of these merely as modifications.

The characteristics used by the author for the determination of *Ceramium* material are given below.

I Cortication only at the nodes throughout the plant

- a The nodal band sharp both upwards and downwards;
paraspores on main branches *C. strictum*
- b The nodal band sharp or proliferating upwards and downwards; paraspores on small branchlets *C. tenuicorne*

II Cortication complete in the upper part of the branches;
the basal part of the filaments with nodal bands *C. rescisum*

III Cortication complete in the basal part of the filaments;
upper part with nodal bands

- a Nodal bands proliferating upwards; end branchlets nearly straight *C. areschougii*
- b Nodal bands proliferating upwards; end branchlets very incurved *C. penicillatum*
- c Nodal bands proliferating both upwards and downwards *C. arborescens*

IV Cortication almost complete; terminal branches with
hardly separated nodal bands *C. rubriforme*

V Cortication complete in the whole plant

- a Gonimoblasts and tetrasporangia at the upper part of
the main branches *C. rubrum*
- b Gonimoblasts and tetrasporangia only at small, special
branchlets *C. pedunculatum*

Ceramium arborescens J. Ag.

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935); Blekinge, Levring (1940); Gotland, Waern (1952).

Denmark: All districts except Smålandshavet and Bornholm.

This species is highly variable and one can find transitional stages to *Ceramium areschougii* and *Ceramium rubriforme*. This variation is probably due to different environmental factors and perhaps also the age of the plants. *Ceramium arborescens* is found abundantly in the Öresund area growing from 0.5 - 15 m in depth epiphytically on different algae, such as fucoids and *Furcellaria fastigiata*. In the south part it is found mainly from 4 - 10 m in depth.

Growth starts at the beginning of March. Fully developed, 6 - 12 cm long, plants are found from May to August. During this time gonimoblasts and tetrasporangia are observed. In the south part of the area only tetrasporic specimens have been observed.

Localities: Abundant in the whole area except the southernmost part.

Polyhalobe pleioeuryhaline.

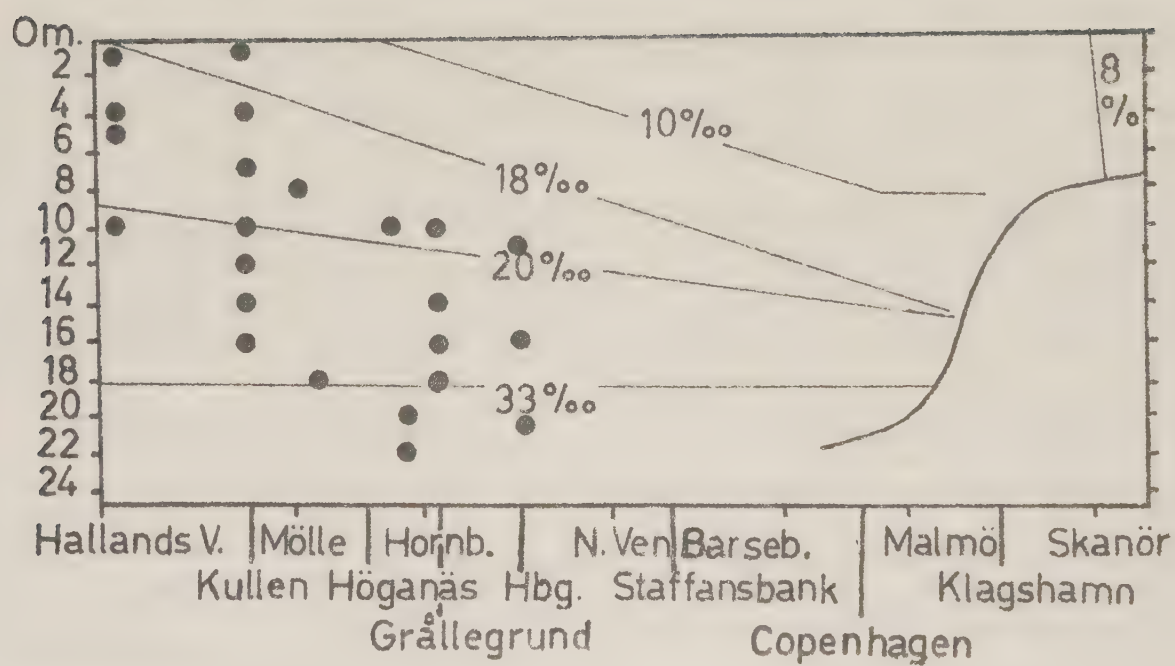


Fig. 95. The distribution of *Ceramium areschougii* in relation to depth and salinity.

Ceramium areschougii Kylin

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935).

Denmark: Kattegatt, Samsö, Little Belt, Öresund, W. Baltic.

This species is frequently found in the north part of the area from (1) - 5 - 25 m in depth, most abundantly between 10 - 18 m in depth. It grows on different algae. The plants are 6 - 15 cm long. Specimens with sexual organs and tetrasporangia have been met with from May to August.

Localities: Off Hallands Väderö, Kullen, Mölle, Vattenmöllan, Gilleleje, Hornbaek Bay, Grållegrund, W. Helsingborg. (Fig. 95)

Polyhalobe meioeuryhaline.

Ceramium pedicellatum (Duby) J. Ag.

Distribution Sweden: Bohuslän, Kylin (1944).

Denmark: -

This species is very difficult to distinguish from *Ceramium rubrum*. As the author has found transitional stages between these species, he is bound to consider *Ceramium pedicellatum* as a deep-water modification of *Ceramium rubrum*. "Pedicellatum forms" are frequently found together with *Ceramium rubrum* in the north part of the area at 15 - 25 m in depth growing on *Furcellaria fastigiata*. The plants are 8 - 12 cm long. Specimens with tetrasporangia have been found from June to September.

Localities: Off Hallands Väderö, off Kullen, Vattenmöllan, Gilleleje flack, Hornbaek Bay, Grållegrund.

Polyhalobe meioeuryhaline.

Ceramium penicillatum Aresch.

Distribution Sweden: Bohuslän, Kylin (1944).

Denmark: N. Kattegatt, Rosenvinge (1923-24), one find.

This species is easily recognized in situ by its typical way of branching, with few and very distinct main axes and lateral branches. But on closer examination it is probably only a modification of *Ceramium fruticulosum* (Kütz.) J. Ag. growing at very exposed localities. It has been found on two occasions at the north side of Kullen at very exposed localities just below the 0-line. Only sterile specimens have been found in June and September.

Locality: Kullen.

Polyhalobe meioeuryhaline.

Ceramium rescissum Kylin

Distribution Sweden: Bohuslän, Koster, Kristineberg, Kylin (1944).

Denmark: N. Kattegatt.

One single specimen of *Ceramium rescissum* has been found west of Kullen

in a dredge haul from 20 m in depth in June. Whether the specimen really was attached or drifting is hard to say, but it looked quite healthy. The specimen, which fully agreed with Kylin's description, was 4 cm long and sterile.

Locality: Kullen.

Polyhalobe oligoeuryhaline.

Ceramium rubriforme Kylin

Distribution Sweden: ?

Denmark: N. Kattegatt, Rosenvinge (1923-24), one find.

Kylin (1907) described *Ceramium rubriforme* from the Swedish west-coast. Later Kylin (1924, 1944) changed his opinion and considered this species to be young stages of *Ceramium arborescens*. Taylor (1937, 1957), however, considered it to be a proper species. Jaasund (1965) is of the opinion that *Ceramium rubriforme* is a complex of species.

The author has frequently found *Ceramia* which agree very well with the description of *Ceramium rubriforme*. With the naked eye they can hardly be separated from *Ceramium rubrum*, although they seem to be a little more red-violet in colour. Under the microscope, however, they are quite distinct. *Ceramium rubriforme* has very faint nodal bands which are covered with a cell layer in a typical pattern which more or less covers the whole thallus except small parts, often only one or two cells large, in the middle of the internodes. In the youngest lateral branchlets very narrow naked bands can be found between the nodal bands. These specimens seem to be constant and show very little morphological variation.

In the large, examined material of *Ceramia* from the Öresund there also exist many transitional forms between *Ceramium areschougii* and *Ceramium arborescens* and forms resembling *Ceramium rubriforme*. All these are probably old stages of *Ceramium arborescens*; not young stages as Kylin (1944) stated.

Ceramium rubriforme is frequently found in the whole area from 1 - 15 - (20) m in depth, growing on stones, shells and larger algae. The author has also found it in the Baltic proper near Öland. The species is found throughout the year. No sexual plants have been observed but plants with tetrasporangia have been met with during nearly all months of the year.

Localities: Frequent in the whole area.

Polyhalobe pleioeuryhaline.

Ceramium rubrum (Huds.) C. Ag.

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935); Blekinge, Levring (1940); Åland, Waern (1952).

Denmark: All districts.

Ceramium rubrum is commonly found in the whole Öresund area but the number of specimens seems to be lower in the south part. It grows from 0.2 m below the 0-line to 10 - (20) m in depth on stones and shells and epiphytically on larger algae. In the north part of the area *Ceramium rubrum* is belt-forming from 0.2 - 1.5 m below the 0-line on stones together with *Ceramium strictum* s.l. and *Polysiphonia nigrescens*. Belt-forming *Ceramium rubrum* of this kind is not found either along the other parts of the Swedish west-coast or in the Baltic. This *Ceramium* belt seems to be sensitive to temperatures below 0°C and is often damaged or killed by low temperature in connection with low water.

Fully developed epiphytically specimens usually are 8 - 15 cm long. Belt-forming plants are only 3 - 5 - (8) cm long. As an epiphyte in the sublittoral

zone the species is found throughout the year. The new plants begin their growth in January and February and are fully developed in April. The belt-forming *Ceramium rubrum* is found from October to February. Sexual plants are found in summer from April to September and plants with tetrasporangia from April to November.

Localities: Common in the whole area.

Polyhalobe pleioeuryhaline.

Ceramium strictum Harv. s.l.

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935); Öresund, Sjöstedt (1928 a); Blekinge, Levring (1940).

Denmark: All districts.

In the North Sea the delimitation between *Ceramium strictum* Harv. and *Ceramium diaphanum* (Lightf.) Roth is quite distinct. (The author has studied these species at Helgoland.) In Kattegatt, Öresund and most noticeably in the Baltic the strictoid *Ceramia* are extremely variable. It is hardly possible to make a correct determination of these forms of which many are probably only modifications. This question has been discussed for a long time by many authors, i.a. Sjöstedt (1928 a,b), Kylin (1924), Du Rietz (1930 a), Levring (1940) and Waern (1952). For the time being the author includes all diaphanoid and strictoid forms except *Ceramium tenuicorne* (Kütz.) Waern in *Ceramium strictum* Harv. s.l.

Ceramium strictum s.l. is common in the whole Öresund area from 0 - 20 m in depth, either on stones or epiphytically on different algae. In the north part of the area it is belt-forming from the 0-line down to 0.5 m in depth. South of Helsingborg, but most prominent south of Barsebäck, the species forms a broad belt from about 0.5 m below the 0-line to 2 m in depth.

The thalli are 3 - 5 - (6) cm long and the colour varying from very light red to dark violet. On the threshold between Malmö and Copenhagen, at 6 - 8 m in depth, *Ceramium strictum* s.l. grows in short, 1 - 3 cm long, dense "tufts" with a dark red-violet colour. During spring the specimens which grow near the surface are more or less, depending on depth, covered with colourless hyaline hairs, probably due to the high light intensity. The species is found throughout the year but the littoral form in the north part is mainly seen from August to February. Sexual plants have been observed from May to October and specimens with tetraspores and paraspores from May to December.

Localities: Common in the whole area.

Polyhalobe pleioeuryhaline.

Ceramium tenuicorne (Kütz.) Waern

Distribution Sweden: Öregrund, Waern (1952).

Denmark: The Baltic proper.

As stated above, the species delimitation of the Baltic strictoid *Ceramia* is very complicated. Waern (loc.cit.) suggested that all these forms belong to *Ceramium tenuicorne* (Kütz.) Waern and that this species should be a real brackish-water alga. In the Öresund area *Ceramium tenuicorne* is found mixed with *Ceramium strictum* s.l. The delimitation of these two species can often be very difficult, but the occurrence of paraspores on small branchlets (*C. tenuicorne*) and paraspores on the main branchlets (*C. strictum* s.l.) seems to be a distinguishing character.

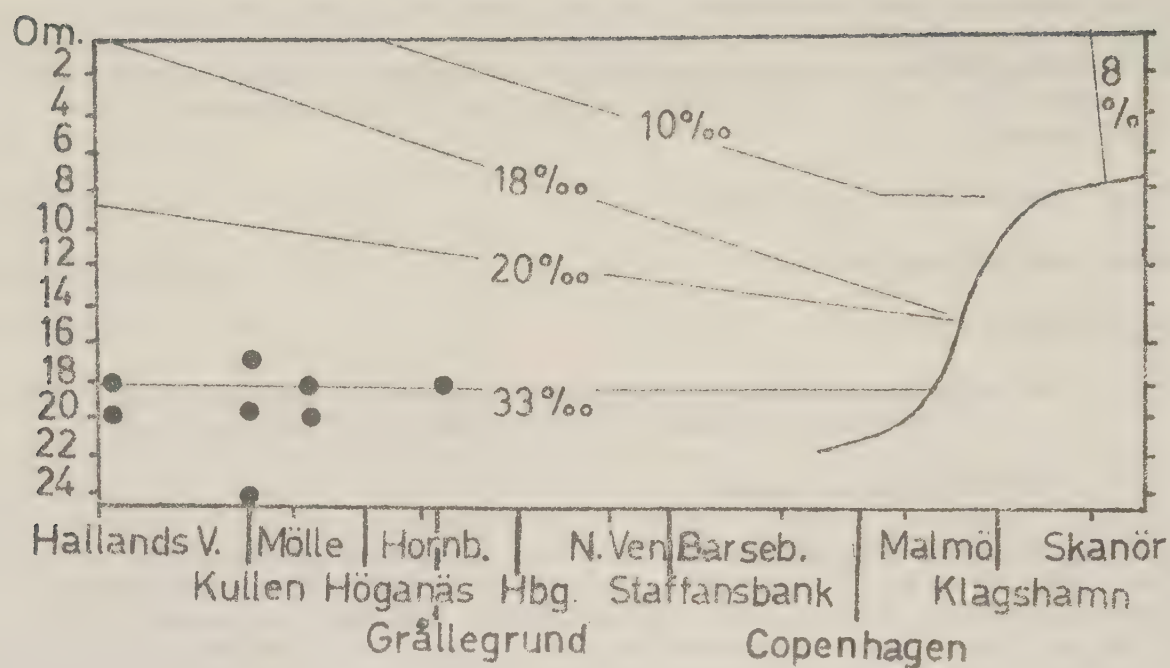


Fig. 96. The distribution of *Plumaria elegans* in relation to depth and salinity.

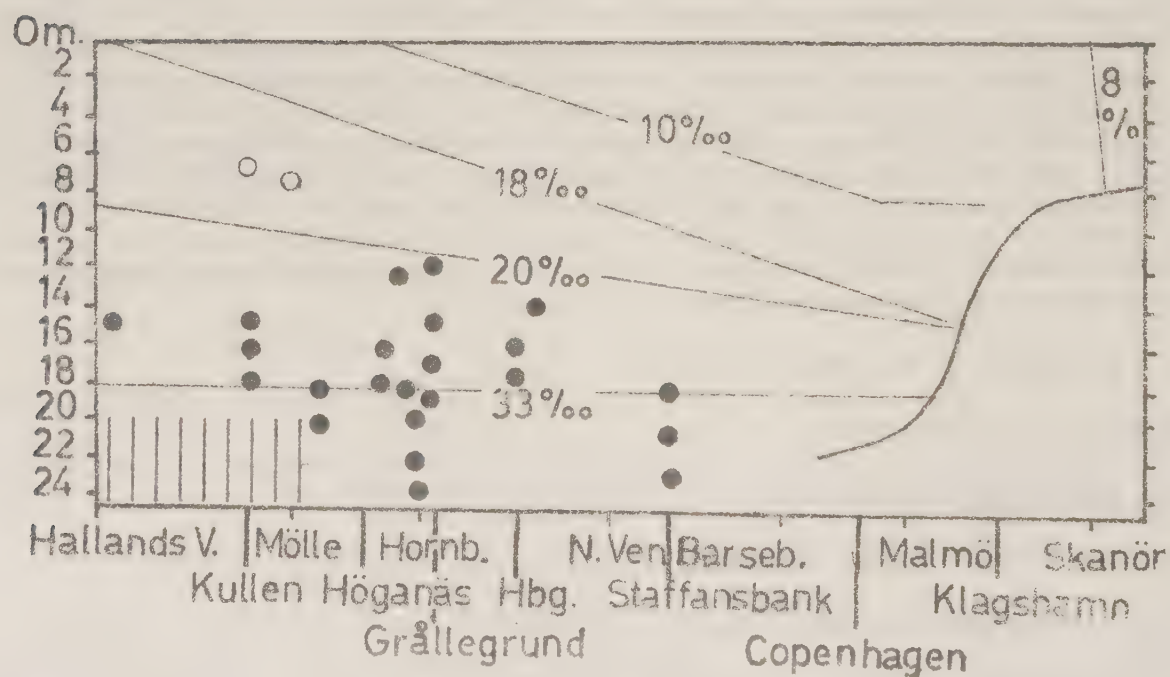


Fig. 97. The distribution of *Ptilota plumosa* in relation to depth and salinity.

||||| common O reduced specimens

Ceramium tenuicorne is abundantly found in the south part of the area, from Klagshamn and southwards, from 0.2 - 1.5 - (7) m in depth. It is belt-forming between 0.2 - 1.5 m in depth. From 1.5 - 7 m only solitary specimens are found.

The specimens vary in length from 3 - 7 - (8) cm. Sexual plants seem to be small and tetrasporophytes larger, 5 - 8 cm long. The species is found throughout the year. The growth begins in February - March. Specimens with gonimoblasts, tetrasporangia and paraspores are found from April to September.

Localities: Klagshamn, Bredgrund, the canal of Falsterbo, Skanör.

Polyhalobe pleioeuryhaline.

Plumaria elegans (Bonnem.) Schm.

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Hallands Väderö, Suneson (1941); Blekinge (one find), Levring (1940).

Denmark: N. Kattegatt, Öresund (one find).

This species is fairly common in Kattegatt, e.g. at Great and Little Middlegrund (dredged by the author). In the Öresund area it is sparsely found in the waters around Hallands Väderö and in the Öresund proper only on five occasions, growing from 17 - 25 m in depth. A specimen, 6 cm long, in the herbarium of the Botanical Museum in Copenhagen, collected south of Helsingör at Disken by dr. J. B. Hansen, is apparently a drifting specimen. Levring's (loc. cit.) find in Blekinge is surprising. The specimens in the Öresund proper, which were only 1 - 2 cm long, were growing on *Furcellaria fastigiata* (one find), *Chondrus crispus* (one find) and on shells.

The finds were made from February to June. No plants with paraspores or sexual organs have been found but plants with tetraspores in two cases.

Localities: Off Hallands Väderö, Kullen, Vattenmöllan, Grålleggrund. (Fig. 96)

Polyhalobe oligoeuryhaline.

Ptilota plumosa (Huds.) C. Ag.

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935).

Denmark: Kattegatt, Öresund.

This very beautiful alga is found in the Öresund area south to Landskrona. In the area around Hallands Väderö it is common at 20 m in depth. At Kullen and Mölle some single specimens have been found from 7 m in depth, very small and reduced. The main part of the species is found from (15) - 20 - 27 m in depth. At 20 - 25 m in depth *Ptilota plumosa* together with *Antithamnion plumula*, besides *Corallina officinalis* and *Lithothamnion* sp., form the main part of the vegetation. In the area between Höganäs and Helsingborg the species is sparse from 15 - 25 m in depth. South to Landskrona the species is found irregularly. The species grows on *Laminaria* hapters and on stones and shells.

Specimens found above the halocline, situated at 12 - 15 m in depth, are 1 - 3 cm long and 0.5 - 0.8 cm broad. Below the halocline the species seems to be best developed at 20 m in depth. Here the length of the thalli is 10 - 12 cm and the breadth 2 - 3 cm. Between Höganäs and Helsingborg the specimens are only 3 - 5 cm long and 1 - 2 cm broad. The growth of the new shoots begins in January or February and they reach a length of 2 cm in August to September. Plants with tetrasporangia are frequently found north of Höganäs from May to September, plants with gonimoblasts in low numbers from June to September; on one occasion in February.

Localities: Off Hallands Väderö, Kullen, off Mölle, Vattenmöllan, Gilleleje flack, Ellekilde hage, Hornbaek Bay, Grållegrund, W. Helsingborg, Knähaken, Staffansbank. (Fig. 97)

Polyhalobe meioeuryhaline.

Spermothamnion repens (Dillw.) Rosenv.

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935).

Denmark: All districts except the Baltic proper.

Spermothamnion repens is a fairly common epiphyte in the Öresund area. It grows abundantly in the north part and frequently in the central part from (7) - 10 - 27 m in depth, mainly on *Chondrus crispus*, *Desmarestia aculeata*, *Furcellaria fastigiata* and *Phyllophora* sp. It often grows together with *Trailliella intricata*.

The specimens are 0.2 - 0.7 - (1) cm long and can sometimes cover large parts of the host. The species is found throughout the year. The major part of the observed material has lacked reproductive organs. Specimens with tetrasporangia are sparse, and spermatangia and carpogonia have only been observed a few times from May to September.

Localities: Hovs Hallar, off Hallands Väderö, Kullen, Mölle, Vattenmöllan, Gilleleje flack, Ellekilde hage, Hornbaek Bay, Grållegrund, W. Helsingborg, Knähaken, Ven, Staffansbank, off Barsebäck. (Fig. 98)

Polyhalobe meioeuryhaline.

Delesseriaceae

Delesseria sanguinea (Huds.) Lamour.

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935); Blekinge, Levring (1940).

Denmark: All districts.

Delesseria sanguinea is, together with *Furcellaria fastigiata* and *Phycodrys rubens*, the dominant species of the red algal vegetation in the north and central part of the Öresund from (7) - 10 - 25 m in depth. In the south part it is sparse. The species grows on stones, shells and large algae.

The size of the plants varies with depth and salinity. Above the halocline the phylloids are 4 - 8 cm long and 0.5 - 1.5 cm broad, below the halocline up to 20 cm long and 2 - 3 cm broad. South of Malmö the Baltic forms *f. filiformis* and *f. lanceolata* are found. These forms are only 3 - 5 cm long and 2 - 4 mm broad, most probably only modifications. The blades are shed in October - November and new blades begin to grow in January. They are 2 - 3 cm long in March and fully developed in May. Cystocarps as well as tetrasporangia are found from December to April. (Fig. 99)

Localities: Common in the north and central part; Kalkgrundet, Oskarsgrundet, W. Klagshamn, Bredgrund. (Fig. 99)

Polyhalobe pleioeuryhaline.

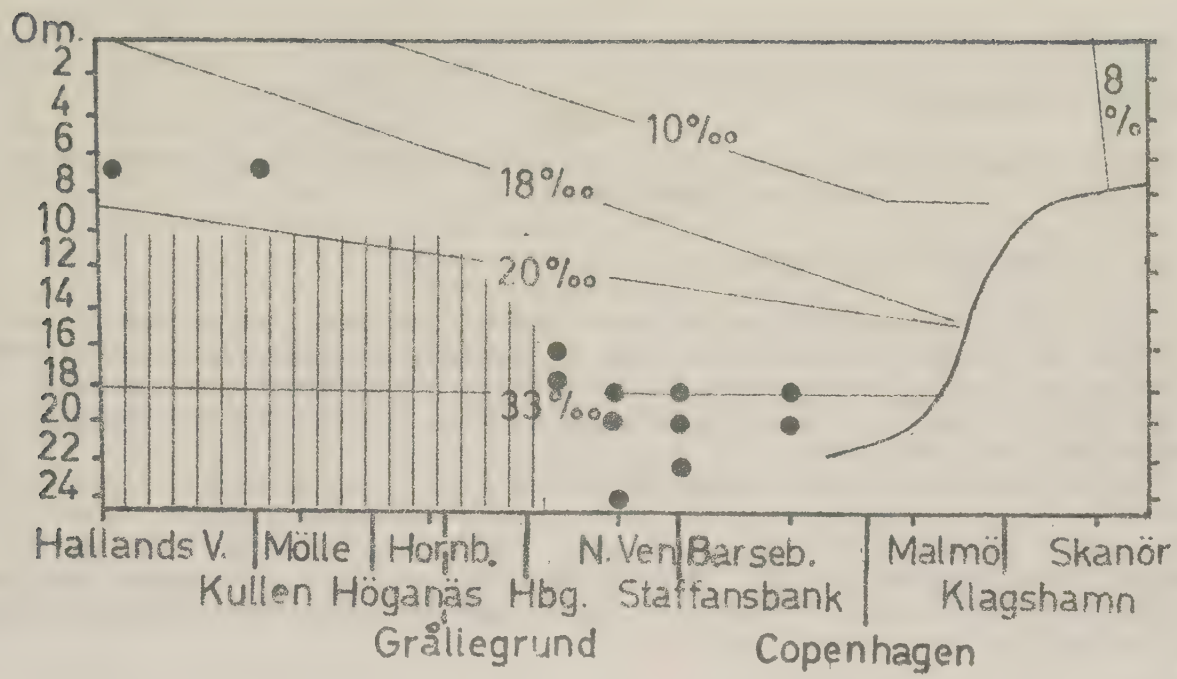


Fig. 98. The distribution of *Spermothamnion repens* in relation to depth and salinity.

||||| abundant

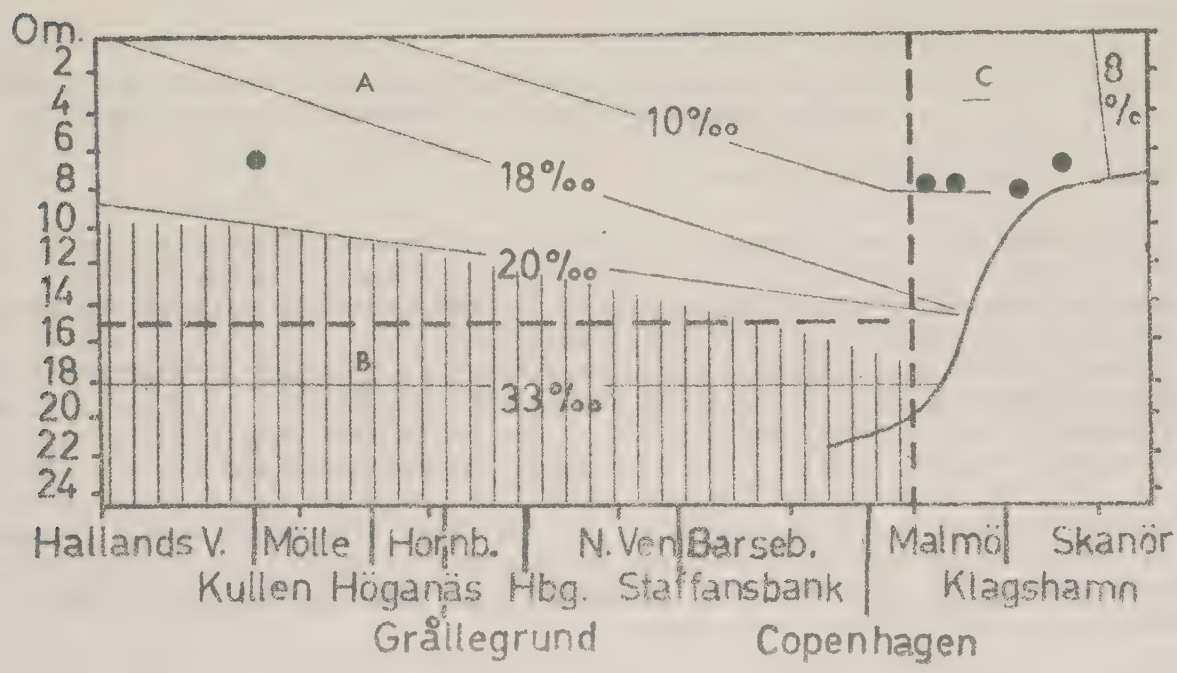


Fig. 99. The distribution of *Delesseria sanguinea* in relation to depth and salinity.

||||| common

A specimens with small blades
B specimens with large blades
C reduced forms

Membranoptera alata (Huds.) Stackh.

(Delesseria alata Harv.)

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935); Simrishamn, Krok (1869).

Denmark: All districts.

The species is abundant in the north and central part and sparse in the south part. At Kullen the species occurs at shaded and exposed localities from 1 m below the 0-line. Otherwise it is found below 5 m in depth and the main distribution is from 10 - 20 m in depth, growing on stones, shells, *Delesseria sanguinea* and *Phycodrys rubens*.

In the north part of the area the plants are 4 - 10 cm long and 2 - 4 mm in breadth. South of Helsingborg the plants are 3 - 5 cm long and 1 - 2 mm in breadth. Some specimens from the south part, Bredgrund, were 2 cm long and 1 mm broad and were similar to Rosenvinge's f. *baltica*, but this form is most probably a low salinity modification. Plants with tetrasporangia and gonimoblasts are frequently found in December to April.

Localities: Abundant down to Malmö - Copenhagen; Kalkgrundet, Oskarsgrundet, Bredgrund.

Polyhalobe pleioeuryhaline.

Phycodrys rubens (L.) Batt.

(Delesseria sinuosa Harv.)

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935); Blekinge, Levring (1940); Småland and Gotland, Svedelius (1901).

Denmark: All districts.

This species is very common in the north and central part of the area. South of the line Malmö - Copenhagen it is more sparsely found. It grows from 8 - 27 m in depth on stones, shells and large algae. In some cases 50 - 70% of the material from dredge hauls consists of *Phycodrys rubens*.

Like the case in *Delesseria sanguinea*, there is a marked difference in size between specimens from above and below the halocline. From 8 - 15 m the main part of the material is 2 - 8 cm long and 0.7 - 1 cm broad with many blades, growing together into "balls". From 15 - 25 m in depth the specimens are 6 - 8 - (10) cm long, 2 - 3 - (4) cm broad and heavily lobed. The specimens found south of Malmö are reduced to about 1 - 2 cm long and 3 - 6 mm broad. The morphological variation of the lobation and the occurrence of papillae is great. Cystocarps and tetrasporangia are frequently found from December to March (- April). In the south part no reproductive organs have been found.

Localities: Common in the whole area south to Malmö - Copenhagen; Kalkgrundet, Oskarsgrundet, W. Klagshamn, Bredgrund.

Polyhalobe pleioeuryhaline.

RhodomelaceaeBroggiartella byssoides (Good. et Woodw.) Schm.

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935).

Denmark: Kattegatt, Samsö, The Belts, Öresund.

The species is abundant in the north part of the area and sparsely found in the central part. It grows from 10 - 25 m in depth on stones, shells and algae, i.a. *Desmarestia aculeata*, *Furcellaria fastigiata*, *Laminaria hapteris*, *Odonthalia dentata* and *Phyllophora* sp.

Growth begins in February, the plant being 0.5 - 1 cm long in March. Growth is slow during spring and at the beginning of June the plant is 2 - 4 cm long. The maximum development is reached in August when the plant in the north part is 12 - 16 cm long. Growth seems to be enhanced by higher temperatures. Culture studies have shown that material, grown at a salinity of 35 o/oo, a temperature of 18 - 20 °C and very low light intensity, reach maximum length, 14 - 16 cm, at the beginning of June. The maximum length recorded by Rosenvinge (1923-24) in Kattégatt is 23 cm. South of Helsingborg - Helsingör the species is hardly longer than 4 cm, and at the southernmost localities in Lomma Bay the maximum length does not exceed 2 cm. The species is found from February to November with tetrasporangia from July to October in the whole distribution area. Cystocarps are found from July to September only on material collected south to Grållegrund.

Localities: Abundant in the north part; Knähaken, Ven, Staffansbank, W. Barsebäck, Lomma Bay, Saltholm flack.

Polyhalobe meioeuryhaline.

Laurencia pinnatifida (Huds.) Lamour.

Distribution Sweden: Bohuslän and north Halland (Råö), Kylin (1944); Kullen, Levring (1935).

Denmark: Kattégatt, Samsö.

There are two previous records of this species from Kullen, by Areschoug (1850) and Levring (loc.cit.). The latter found some specimens about 2.5 cm long on *Fucus vesiculosus*. The author has never observed the species in fully developed stages in the Öresund. On concrete blocks which were laid out at Kullen at different depths in order to study the algal colonization, young stages like the one depicted by Rosenvinge (1923-24) were found in very high numbers from 4 - 10 m in depth in October and November. These juvenile stages did not survive and no developed specimens were observed.

The finds at Kullen show that diaspores are probably driven south from the distribution area in north Kattégatt by currents and that they can under certain circumstances, e.g. high salinity, germinate, but as a rule they do not reach more developed stages in the average salinity found in south Kattégatt and Öresund.

Locality: Kullen.

Polyhalobe oligoeuryhaline.

Odonthalia dentata (L.) Lyngb.

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935).

Denmark: Kattégatt, Samsö, Great Belt, Öresund.

Odonthalia dentata is abundant in the north and frequent in the central part of the Öresund south to Barsebäck, growing from (10) - 15 - 27 m in depth on stones and shells. The specimens can be 10 - 15 cm long but the average length is 10 - 12 cm. The new shoots begin their growth in December - January. Plants with tetrasporangia have been observed from December to April. No sexual plants have been found in the Öresund area.

Localities: Off Hallands Väderö, Kullen, Vattenmöllan, Gilleleje, Ellekilde hage, Hornbaek Bay, Grälleggrund, W. Helsingborg, Knähaken, N. Ven, Staffansbank, W. Barsebäck.

Polyhalobe meioeuryhaline.

Polysiphonia brodiaei (Dillw.) Spreng.

Distribution Sweden: Bohuslän and north Halland, Kylin (1944).

Denmark: N. and S. Kattegatt.

This species is very common in Bohuslän and has a characteristic habitat at very exposed localities in the littoral zone on rocks which are covered with a red carpet of the species. South of Varberg there seems to be no previous record of the species.

Polysiphonia brodiaei has been found by the author in the Öresund area on three occasions, in June 1966 (two localities), June 1968 and June 1971. All finds have been made on the north side of Kullen in the littoral zone. The number of observed specimens has varied from 5 to about 30. Kylin (loc.cit) reports the length of the plant in Bohuslän as being 7 - 15 cm. Rosenvinge (1923-24) has found a maximum length in the Danish material of 20 cm. The average length of the plants observed at Kullen is 7 cm. Only one of the examined plants bore cystocarps and no tetrasporangia were observed.

Locality: Kullen.

Polyhalobe meioeuryhaline.

Polysiphonia elongata (Huds.) Spreng.

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935); Ven, Waern (1965 a).

Denmark: All districts.

Levring (loc.cit.) stated, "Ich habe nur vereinzelte Exemplare angetroffen". Nowadays, however, the species is found abundantly in the north part and frequently in the central part. In the south part it is sparse. It grows from 8 - 27 m in depth on stones and shells or on Furcellaria fastigiata or Laminaria hapters.

In the north part the length of the plants is 20 - 25 - (30) cm. South of Helsingborg the specimens are 10 - 20 cm long. South of Malmö only reduced forms, 5 - 10 cm long, resembling Rosenvinge's f. baltica, have been observed. The finds from Bornholm by Rosenvinge (1935) are considered by Schiffner (1939) to be Polysiphonia violacea. The growth of the new shoots begins in February - March and the specimens are fully developed in May. The terminal branches are generally shed in August and September. Plants with tetrasporangia are found south to Malmö from May to September. Specimens with cystocarps have only been observed in the north part of the area from June to August.

Localities: Abundant in the north part; Knähaken, N. Ven, Staffansbank, W. Barsebäck, Salholm flack, Kalkgrundet, W. Klagshamn.

Polyhalobe meioeuryhaline.

Polysiphonia fibrillosa (Dillw.) Spreng.

Distribution Sweden: Bohuslän and north Halland, Kylin (1944).

Denmark: Kattegatt, Samsö, Little Belt, Öresund, Rosenvinge (1923-24).

Rosenvinge (loc.cit.) considered this species to be a form of *Polysiphonia violacea*, as he was of the opinion that the characters for separating them depended on environmental factors. Kylin (loc.cit.) considered it to be a "good species". According to the author's opinion the differences are great enough to maintain *Polysiphonia fibrillosa* and *Polysiphonia violacea* as separate species. However, they are probably closely related. The main differences are the somewhat thicker "central branch", the length of the joints and the richness of secondary auxilliary shoots.

In the Öresund the species is frequently found in the north part from (10) - 15 - 20 m in depth, thus separated from *Polysiphonia violacea* which is seldom met with at these depths. The species grows on shells and on *Furcellaria fastigiata*. The length of the thalli is 8 - 15 cm. Specimens have been observed from February to October with cystocarps and tetrasporangia in June - August.

Localities: Kullen, Vattenmöllan, Hornbaek Bay, Grälleggrund. (Fig. 100)

Polyhalobe meioeuryhaline.

Polysiphonia hemisphaerica Aresch.

Distribution Sweden: Bohuslän, Koster, Brandskären, Areschoug (1875); Bohuslän, Waern (1958); Halland, Varberg, Hylmö (in herbarium, Botanical Museum, Lund); Hallands Väderö, Sjöstedt (1927); Kullen, Simmons (in herbarium, Botanical Museum, Lund).

Denmark: -

The taxonomic status of this species has been discussed for a long time. It was originally described by Areschoug (loc.cit.) from material collected in Bohuslän. It was later confused with *Polysiphonia urceolata* f. *pulvinata* J. Ag. This form, however, has only four pericentral cells. Sjöstedt's (loc.cit.) record at Hallands Väderö was considered as an abnormal *Polysiphonia urceolata* by Kylin (1944). Waern (loc.cit.) drew attention to these questions. These matters and the result of culture studies of the species are discussed by Rueness (1971).

Polysiphonia hemisphaerica which without doubt is a "good species" is sparsely found in the north part of the Öresund area. Two different types have been observed:

a) a small type, 2 - 6 cm long, dark brown - red with a "bushy" appearance, at exposed localities from 0.2 - 1 m below the 0-line, growing together with *Polysiphonia urceolata*;

b) a larger type, up to 10 - 12 cm long, light brown - red, with large branches with few branchlets, growing in low-lying rock-pools.

Whether these two forms deserve taxonomic recognition is hard to say at the moment. The species has been found from April to October and examined specimens have lacked all kinds of reproductive organs.

Localities: Hovs Hallar, Hallands Väderö, Kullen.

Polyhalobe mesoeuryhaline.

Polysiphonia nigrescens (Huds.) Grev.

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935); south and east coast of Scania, Sjöstedt (1920); Blekinge, Levring (1940); Småland and Gotland, Svedelius (1901); Öregrund, Waern (1952).

Denmark: All districts.

The species is very common in the whole Öresund area growing from (0) - 0.5 - 27 m in depth on stones, shells and on algae, e.g. *Fucus serratus*, *Furcellaria*

fastigiata and *Phyllophora* sp. In the north part south to Höganäs the species can be found at exposed localities from just below the 0-line.

The species is very variable but the variation seems to be correlated with depth, salinity and degree of exposure. The littoral forms are often small, only 2 - 6 cm long, and "bushy" while the sublittoral forms are 5 - 20 cm long. In the south part of the area the branchlets are thinner and the whole plant is more slender. *Polysiphonia nigrescens* is found throughout the year with tetrasporangia from April to December and cystocarps from April to October. In the north part of the area the number of tetrasporic and sexual plants is equal. The number of plants with spermatangia, carpogonia and cystocarps is reduced towards the south part of Öresund. In the southernmost area the proportions have been estimated at about 75 % plants with tetraspores and 25 % with cystocarps, which is in agreement with Levring's (1940) and Svedelius' (loc.cit.) observations that sexual plants are lacking or very rare in the Baltic.

Localities: Common in the whole area.

Polyhalobe pleioeuryhaline.

Polysiphonia urceolata (Lightf. ex Dillw.) Grev.

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935); east Scania, Vitemölla, Åhus, Sjöstedt (1920); Blekinge, Levring (1940).

Denmark: All districts except Bornholm.

Polysiphonia urceolata is widely distributed in the whole Öresund. In the north part of the area it is found at shaded and rather exposed localities from 0.3 m below the 0-line down to 25 m in depth. South of Höganäs the species is not found in the littoral zone but from 2 - 3 m in depth; in the south part the upper limit is at 6 - 7 m in depth. The species grows on stones, shells and larger algae.

Specimens in the littoral zone in the north part of the area are small, 2 - 3 cm long, dark red and "bushy". Plants growing from 2 - 15 m in depth are larger, 5 - 6 cm long, and more slender. Individuals from below 15 m are light red and very delicate with very long thin branches. Growth begins in March and plants are fully developed from the beginning of May. The species is found throughout the year with tetrasporangia from June to October in the whole area. Southward to Kullen plants with carpogonia, spermatangia and cystocarps have been observed from May to September.

Localities: Common in the whole area.

Polyhalobe pleioeuryhaline.

Polysiphonia violacea (Roth) Spreng.

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935); Blekinge, Levring (1940); Gotland, Svedelius (1901); Öregrund, Waern (1952).

Denmark: All districts.

Polysiphonia violacea is commonly found in the whole of Öresund from (1) - 5 - 15 m in depth, growing on stones, shells and algae, e.g. *Chorda filum*, *Fucus serratus*, *Laminaria* hapters, *Polysiphonia elongata* and *Polysiphonia nigrescens* and on *Zostera* leaves.

The length of the thalli varies from 10 - 20 cm. Growth begins in February and is vigorous in March - May. During summer very little growth is observed. The species is found throughout the year. In October to December a new generation

begins grow. This has especially been observed in the south part of the area where fishing nets can be overgrown in a short time by dark red-violet specimens, 4 - 10 cm long. Plants with tetrasporangia or cystocarps are found from April to September in the whole area.

Localities: Common in the whole area. (Fig. 100)

Polyhalobe pleioeuryhaline.

Rhodomela confervoides (Huds.) Silva

(*Rhodomela subfusca* (Woodw.) C. Ag.)

Distribution Sweden: Bohuslän and Halland, Kylin (1944); Kullen, Levring (1935); Blekinge, Levring (1940); Småland and Gotland, Svedelius (1901); Stockholm archipelago, Krok (1869); Öregrund, Waern (1952).

Denmark: All districts.

Rhodomela confervoides and *Rhodomela lycopodioides* (L.) C. Ag. may be conspecific, as has been suggested by some authors, i.a. Waern (loc.cit.) and Dixon (1968). The present author has seen material from the Öresund which could fit the description of the latter species. This complex including *Rhodomela virgata* ought to be reviewed.

Rhodomela confervoides is common in the Öresund. It grows from 0.3 - 27 m in depth, south of Helsingborg - Helsingör from (3) - 5 - 27 m in depth, on limestone, shells and larger algae, e.g. *Fucus serratus*, *Furcellaria fastigiata* and *Laminaria stipes* and hapters.

The maximum length in the littoral and the first metre of the sublittoral zone is 6 - 10 cm and from 5 - 6 m in depth 10 - 15 - (18) cm. It is found throughout the year. Growth starts in February. Both Kylin (loc.cit.) and Rosenvinge (1923-24) state that the reproductive organs are found during spring from March to June. Levring (1940) found that the development of these organs was delayed in the Baltic to May - July. The author has found tetrasporangia from February to July and in September to January, (the January find was apparently old sporangia), and cystocarps from April to August. The number of sexual plants is reduced in the south part of the area in comparison with the north part.

At 15 - 25 m in depth in the north part of the Öresund specimens which are similar to *Rhodomela confervoides* f. *gracilis* Aresch. have been found. This form is probably only a modification.

Localities: Common in the whole area.

Polyhalobe pleioeuryhaline.

Rhodomela virgata Kjellm.

Distribution Sweden: Bohuslän, Kylin (1944).

Denmark: All districts except Bornholm, Rosenvinge (1923-24).

The taxonomic status of this species is controversial. Kylin (1907, 1944) and Levring (1937, 1940) are of the opinion that it is a good species, quite distinct from *Rhodomela confervoides* in three aspects:

1. difference in time of reproduction;
2. reproductive organs situated on special branchlets in *Rhodomela virgata*;
3. anatomical differences in the cortical layer.

Rosenvinge (loc.cit.) was of the opinion that these discrepancies could not justify a separation into two species. The find of tetrasporangia on *Rhodomela*

confervoides during autumn and winter raises the question whether the discrepancies are large enough to maintain *Rhodomela virgata* as a species.

Specimens which fit the description of *Rhodomela virgata* are sparsely found in the north part of the Öresund area from 15 - 20 m in depth on shells. Tetrasporangia have been found from January to March.

Localities: Off Hallands Väderö, Gilleleje flack, Hornbaek Bay, Grållegrund.

Polyhalobe oligoeuryhaline.

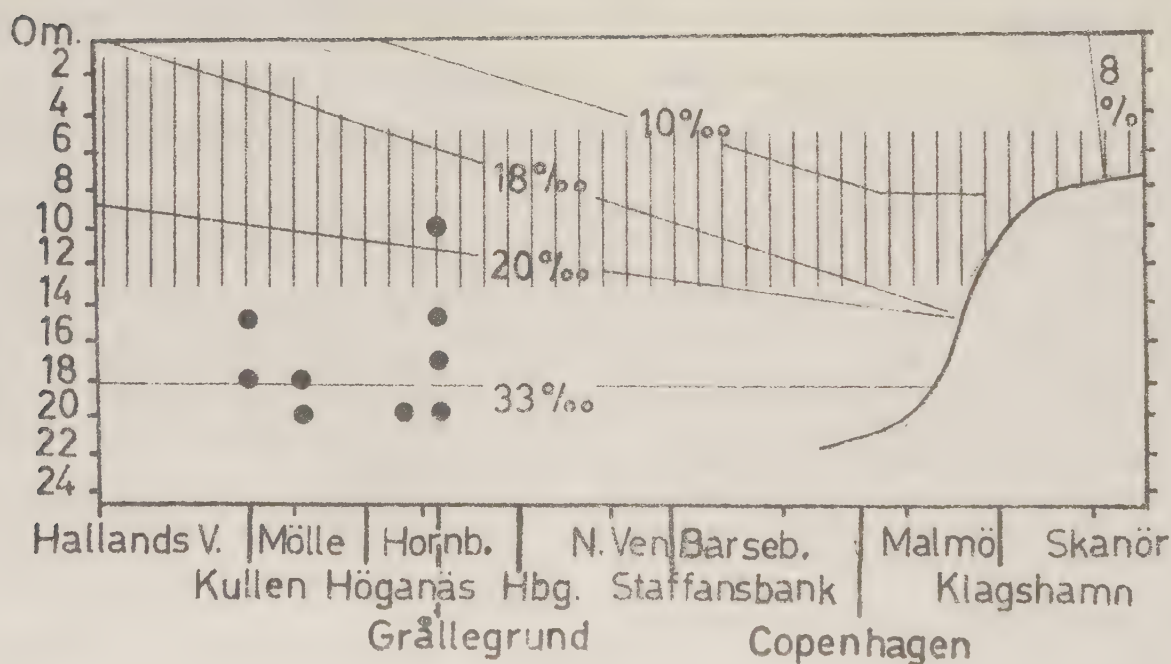


Fig. 100. The distribution of *Polysiphonia fibrillosa* ● and *Polysiphonia violacea* ||||| (common) in relation to depth and salinity.

PHAEOPHYTA

PHAEOPHYCEAE

ECTOCARPALES

There has for some time been a strong demand for revision of the order Ectocarpales, partly the delimitation of the species within Ectocarpus and related genera and partly a need to ascertain the taxonomic status of the epiphytical genera Hecatonema, Myrionema, Streblonema etc. Ravanko (1970 a) has the opinion that the taxonomic boundaries in the Ectocarpaceae are invalid, and she considers Compsonema, Hecatonema and Myrionema as prostages or protonemas to larger species such as Ectocarpus sp. Clayton (1972) gives the evidence that some of Ravanko's results could be affected by contamination in the cultures. Before these questions are fully solved quite a lot of work has to be done on field studies, culture work and perhaps, most important, intense cytological studies. For the time being the author considers it most appropriate to use the traditional taxonomic view.

Ectocarpaceae

Ectocarpus

As stated above, the delimitations between and the taxonomic status of the different species described within the genus Ectocarpus are uncertain. It has been revised several times, i.a. by Papenfuss (1935), Rosenvinge & Lund (1941), Zinova (1953), Feldmann (1954) and Kornmann (1956, 1957). Kylin (1947) shared Kjellman's (1890) opinion that Ectocarpus confervoides, Ectocarpus draparnaldioides, Ectocarpus fasciculatus, Ectocarpus hiemalis, Ectocarpus penicillatus and Ectocarpus siliculosus were "good species". Rosenvinge & Lund (loc.cit.) accepted only three species, Ectocarpus confervoides s.l., Ectocarpus draparnaldioides and Ectocarpus fasciculatus. Ectocarpus hiemalis Crouan, Ectocarpus penicillatus (C.Ag.) Kjellm. and Ectocarpus siliculosus (Dillw.) Lyngb. were included in Ectocarpus confervoides. Even Cardinal (1964) considered Ectocarpus siliculosus to be a form of Ectocarpus confervoides. Papenfuss (loc.cit.) and Kornmann (loc.cit.), however, have shown that Ectocarpus siliculosus has a different life-cycle and should for that reason be kept as a species. In this treatise the author follows Rosenvinge & Lund's delimitation. However, Ectocarpus siliculosus is accepted as a "good species".

Ectocarpus confervoides f. "typica" Kjellm.

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Kullen, Levring (1935); Blekinge, Levring (1940); Gotland, Svedelius (1901); Öregrund, Waern (1952).

Denmark: All districts except Bornholm, Rosenvinge & Lund (1941).

This form is commonly found in the whole area from the 0-line down to 20 - (25) m. It is, however, most abundant between 0 - 10 m in depth. It grows on stones and is epiphytic on different algae. Specimens are found throughout the year but growth is most vigorous in April and May. Sporangia are seen from (April)-May to September. Plurilocular sporangia are found at all depths and vary in size from 14 - 28 μ x 40 - 60 μ ; the majority are 20 x 50 - 60 μ . Unilocular sporangia are frequently found but in low numbers, mainly in material from deep-water localities.

Localities: Common in the whole area.

Polyhalobe pleioeuryhaline.

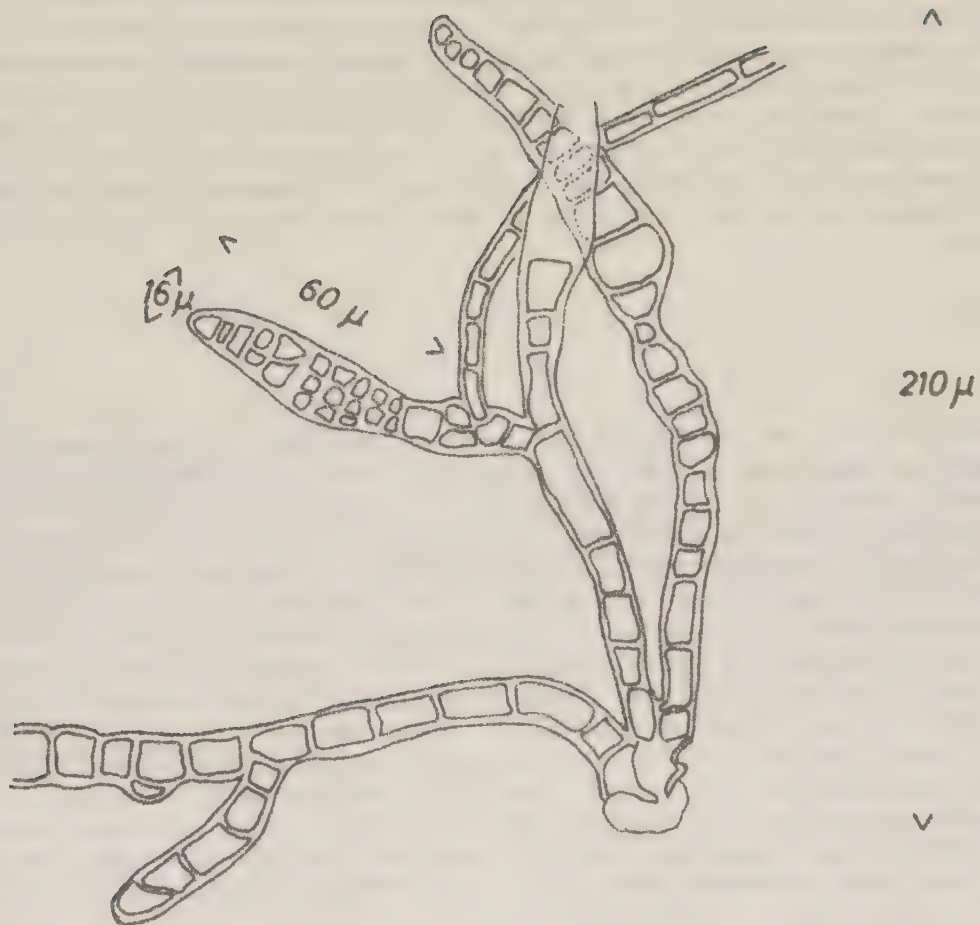


Fig. 101. *Ectocarpus confervoides* f. *pygmæa*.

Ectocarpus confervoides f. hiemalis (Crouan) Kjellm.

Distribution Sweden: Bohuslän and Halland, Kylin (1947).

Denmark: Kattegatt, Little Belt, Öresund, W. Baltic, Rosenvinge & Lund (1941).

This form has only been recorded at a few localities in the whole Öresund area. The majority of the finds were made in the north part. The plant grows from 0.5 - 15 m in depth on different algae. Plurilocular sporangia, 18 - 23 x 250 - 425 μ , have been seen from May to October but most frequently during June to August. Unilocular sporangia, 40 x 110 μ , have been found on a few occasions.

Localities: Kullen, Grälleggrund, Helsingborg, Barsebäck, Bredgrund.

Polyhalobe mesoeuryhaline.

Ectocarpus confervoides f. penicillata (C. Ag.) Kjellm.

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Kullen, Levring (1935); Blekinge, Levring (1940); Öregrund, Waern (1952).

Denmark: Kattegatt, Samsö, The Belts, Öresund, Rosenvinge & Lund (1941).

This form is fairly common but does not seem to occur in such great numbers as f. "typica". The plant is mainly seen at exposed and semi-exposed localities from 0 - 2.5 m in depth. It is common as an epiphyte on *Chordaria flagelliformis* and *Fucus vesiculosus* and to a lesser extent on *Scytosiphon lomentaria*. It is also found growing on stones.

The specimens grow throughout the year but most conspicuously from April to October. The plurilocular sporangia are 12 - 28 x 140 - 160 μ . A few unilocular sporangia, 20 - 30 x 30 - 50 μ , have been found.

Localities: Common in the whole area.

Polyhalobe pleioeuryhaline.

Ectocarpus confervoides f. pygmaea (Aresch.) Lund

Distribution Sweden: Kullen, Levring (1935).

Denmark: Fredrikshamn, Rosenvinge & Lund (1941).

The validity of this form is disputable. Smith (1942) observed lateral openings on the sporangia and considered them to be uniseriate plurilocular sporangia, for that reason suggesting it to be a "good species", *Ectocarpus variabilis* (Saund.) Smith. Jaasund (1965) concluded from field observations that the species was in fact a juvenile stage of *Ectocarpus fasciculatus*. Ravanko (1970 a) reports the occurrence of *Ectocarpus confervoides f. pygmaea* stages in her culture of i.a. *Kuckuckia* sp. Baker & Evans (1971), when culturing *Ectocarpus fasciculatus*, found a *Myrionema corunnae* stage in some cultures but no *pygmaea* stage.

On some occasions during spring very small *Ectocarpus* filaments have been found from 0.5 - 10 m in depth on *Enteromorpha* sp. and *Laminaria saccharina*. These filaments were 200 - 250 μ long with cells 10 - 12 μ broad and bore plurilocular sporangia which were 14 - 16 x 50 - 60 μ . The specimens agreed completely with Lund's (loc.cit.) description. (Fig. 101)

Localities: Kullen, Barsebäck.

Polyhalobe mesoeuryhaline.

Ectocarpus fasciculatus (Griff.) Harv.

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Kullen, Levring (1935).

Denmark: Kattegatt, Samsö, Little Belt, Öresund.

Jaasund (1965) suggested that both *Ectocarpus confervoides* f. *pygmaea*, *Myrionema corunnae* and *Microspongium globosum* could be different stages in the life-cycle of *Ectocarpus fasciculatus*.

This alga has been met with sparsely in the north part of the area, growing in all cases at exposed localities from about 0.5 - 4 m in depth on stones and different algae, such as *Chorda filum*, *Chordaria flagelliformis* and *Laminaria* sp. Plurilocular sporangia have been found from June to September, 13 - 30 x 60 - 120 μ . No unilocular sporangia have been seen in the author's material. It has not been possible to find any myrionemoid stages in connection with *Ectocarpus fasciculatus*.

Localities: Kullen, Gilleleje, Grällegrund.

Polyhalobe meioeuryhaline.

Ectocarpus siliculosus (Dillw.) Lyngb.

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Kullen, Levring (1935); Blekinge, Levring (1940); Öregrund, Waern (1952).

Denmark: All districts.

This species is fairly common in the whole area growing from about 0.5 - 20 - (25) m in depth on stones and different algae. When specimens reach a certain size, about 10 cm, they often become detached and are then found lying loose, sometimes in huge masses, often together with detached *Ectocarpus confervoides* f. "typica". The species is found mainly from February to November. Plurilocular sporangia have been found from April to October and are mainly 12 (11 - 15) μ wide and 100 - 275 μ long. A few unilocular sporangia have been observed of 20 - 25 x 25 - 40 μ .

Localities: Common in the whole area.

Polyhalobe pleioeuryhaline.

Microsyphar polysiphoniae Kuck.

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Kullen, Levring (1935); Öregrund, Waern (1952).

Denmark: -

This endophytic brown alga is reported growing exclusively in *Polysiphonia* sp. (mainly *P. urceolata*) by Kylin (loc.cit.) and Jaasund (1965). Printz (1926) reports it in *Cladophora glomerata*. In the Baltic, Waern (loc.cit.) mentions the species from *Chaetomorpha* sp. and *Cladophora* sp.

In the Öresund *Microsyphar polysiphoniae* is a rather common endophyte from 0.5 - 15 - (20) m in depth, most abundantly from 1 - 10 m. It grows in different red algae, such as *Ceramium rubrum*, *Polysiphonia elongata*, *Polysiphonia nigrescens*, *Polysiphonia urceolata*, *Polysiphonia violacea* and *Rhodomela confervoides* but also more seldom in *Cladophora rupestris*. A few finds have also been made in *Ectocarpus* sp. and *Pilayella* sp.

The filaments are 6 - 8 - (9) μ thick. The cells are often rounded, but sometimes they are 10 - 14 μ long. Old specimens can almost grow into a pseudo-

parenchyma which can cover large parts of the host. When living material is examined the colour of the endophyte is light brown to yellow brown, which makes it easy to detect. The species is found throughout the year but most conspicuously from April to October. Plurilocular sporangia are not common.

Localities: Common in the whole area.

Polyhalobe pleioeuryhaline.

Microsyphar porphyrae Kuck.

Distribution Sweden: Bohuslän, Koster, Kristineberg, Malö, Kylin (1907); Kullen, Levring (1935).

Denmark: Skagerack.

Old thalli of *Porphyra* sp. are often infected with several epiphytes and endophytes, such as *Acrochaetium cytophagum*, *Acrochaetium parvulum* and *Leptonematella fasciculata*. On two occasions the author has found some specimens of *Microsyphar porphyrae* on *Porphyra purpurea*, collected at Kullen near the O-line. The species is probably very rare, though it is easily overlooked.

The filaments were 3 - 6 μ thick and in many cases they terminated in a hair which penetrated the surface of the thallus. The hair had a marked "collar". The specimens were observed in June and August. A few plurilocular sporangia, consisting of only 2 - 3 cells, were observed.

Locality: Kullen.

Polyhalobe mesoeuryhaline.

Microsyphar zosterae Kuck.

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Blekinge, Levring (1940).

Denmark: -

The *Zostera* leaves are a well-known habitat for many microscopic algae. Special attention has been directed to these forms and a large material has been collected. In one collection from the vicinity of Landskrona, made in October at 3 m in depth, some specimens of *Microsyphar zosterae* were found. The filaments were single and had not grown into a pseudoparenchyma. Only a few plurilocular sporangia were seen. The cells of the filaments were 4 - 6 μ broad, 1 - 2 times as long.

Locality: Gräsrännan (Landskrona).

Polyhalobe pleioeuryhaline.

Spongonema tomentosum (Huds.) Kütz.

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Kullen, Levring (1935); Blekinge, Levring (1940).

Denmark: Kattegatt, Samsö, The Belts, Öresund, W. Baltic.

Spongonema tomentosum is abundant in the north part of the area but shows a decreasing frequency towards the south part and seems to be sparse south of Malmö. The most developed and highest number of specimens are found at very exposed localities, where the hosts can be practically overgrown by *Spongonema tomentosum*. At semi-exposed localities one can find the species in low numbers and

not so well developed. At quite sheltered localities it does not seem to survive. *Spongonema tomentosum* grows from 0.1 - 1 m below the 0-line, most abundantly on *Fucus serratus* and *Fucus vesiculosus* and sometimes even on *Ascophyllum nodosum*. Jaasund (1965) mentions some finds of *Spongonema tomentosum* on stones but the author has not been able to find the species on stones.

The first sign of this alga can be seen in February and the tufts reach their maximum length in May to June when they are about 5 - 6 cm long. Kylin (loc. cit.) gives the length of the thallus as 5 - 10 cm; Kuckuck (1960) from Helgoland as 10 - 15 cm. The length of the *Spongonema* tufts decreases during summer, probably due to mechanical wear. During October and November the thalli are rapidly decomposed. Plurilocular sporangia, 11 - 14 x 50 - 100 μ , in some cases uniseriate sporangia, have been found from May to October. No unilocular sporangia have been found in the area.

Localities: Abundant in the north part, frequent in the central part; Klagshamn, Skanör.

Polyhalobe pleioeuryhaline.

Sorocarpus uvaeformis Pringsh.

(*Sorocarpus micromorus* (Bory) Silva)

Distribution Sweden: Bohuslän, Kristineberg, Kjellman (1891).

Denmark: N. and S. Kattegatt, Samsö, Little Belt, Öresund, W. Baltic.

Of this ectocarpaceæ there are very few observations from Scandinavian waters. From Sweden there are, apart from Kjellman's (loc. cit.) find, a few observations from Varberg, Levring (personal communication). In Öresund there is one find near Ellekilde hage on *Callithamnion fruticulosum*, Rosenvinge & Lund (1941).

The author has once seen a small specimen of *Sorocarpus uvaeformis* at Kullen in August, growing in a depth of about 1 m on *Cladophora rupestris*. The specimen was about 1 cm high and bore typical sori of plurilocular sporangia, which were about 8 - 12 x 20 - 25 μ .

Locality: Kullen.

Polyhalobe meioeuryhaline.

Streblonema immersum Levring.

Distribution Sweden: -

Denmark: -

This minute endophyte which Waern (1952) characterises as "one of the smallest brown algae heard of" was described by Levring (1937) from material growing in *Dumontia incrassata* from Norway. Jaasund (1965) has recorded a few finds of this alga in *Dumontia incrassata*.

The geographical distribution of this alga is difficult to consider because of the scanty information in the literature. It is hard to say whether it is common or not because it is so easily overlooked but it seems to be rare in the Öresund region. In spite of looking through a rather large material of *Dumontia incrassata* and other loosely-knit algae, the author has found the species only once in *Dumontia incrassata* material collected in June at Lerhamn from 0.75 m in depth.

The specimens showed a close agreement with Levring's description. The plantlets were fully endophytic. Only few hairs and no plurilocular sporangia

penetrated the cortex cells of the host. The basal cells were $2.5 - 4 \times 10 - 16 \mu$; near the plurilocular sporangia the cells were $2.5 - 4 \times (4) - 6 - 10 \mu$. The plurilocular uniseriate sporangia were $3.5 - 5 \times 11 - 22 \mu$.

Locality: Lerhamn.

Polyhalobe meioeuryhaline.

Waerniella lucifuga (Kuck.) Kylin

Distribution Sweden: Bohuslän, Kristineberg, Soteskär, Waern (1940); Kullen and Blekinge, Levring (1940); Öregrund, Waern (1936).

Denmark: Little Belt, Öresund, Bornholm.

Silva (1959) has transferred this genus to Leptonematella, but the author cannot agree with this. *Waerniella lucifuga* is one of the few real cave algae found in Sweden. It was for a long time overlooked, but was found by Waern (1936) and he summed up the known distribution in Europe (1940, 1952).

In the Öresund *Waerniella lucifuga* is found abundantly in the supralittoral zone up to 5 m above the 0-line at pertinent localities, caves or between large stones in piers and breakwaters. It often but not always grows together with *Rhodochorton purpureum*. *Waerniella lucifuga* must be protected from direct sunlight and must always have a high relative humidity, not below 90 % for any length of time.

In most cases the alga forms small spots up to 1 dm^2 but in some caves at Kullen it grows in a dense carpet of about 10 m^2 . The filaments observed are 200 - 400 μ long and 5 - 7 μ broad. The species is found throughout the year but seems to be best developed during March - May and September - November. Plurilocular sporangia seem to be sparse.

Localities: Hallands Väderö, Kullen, Gilleleje, Helsingör, Helsingborg, Råå, Skogshoved, Barsebäck, Skanör.

Polyhalobe pleioeuryhaline.

Ralfsiaceae

Lithoderma fatiscens Aresch.

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Kullen, Levring (1935); Blekinge, Levring (1940); Öregrund, Waern (1952).

Denmark: Öresund, Lund (1938).

The delimitations between different forms in *Ralfsia* and *Lithoderma* have long been controversial. The discussion is summed up by Lund (loc.cit.) and Kylin (loc.cit.). Lund (1959 a) was of the opinion that the *Lithoderma* crusts in northern waters should be considered as *Lithoderma fatiscens* Aresch. emend Waern and *Pseudolithoderma extensum* (Crouan frat.) Lund. Waern (1949, 1952) advocated that the Swedish *Lithoderma* crusts consisted of *Lithoderma fatiscens* Aresch. emend Waern, *Lithoderma extensum* (Crouan) Hamel and *Sorapion kjellmanii* (Wille) Rosenv. Furthermore, Waern added from the Baltic two new species, *Lithoderma rosenvingii* Waern and *Lithoderma subextensum* Waern besides *Petroderma maculiforme* (Wollny) Kuck. The latter has later been reported from Öresund by Lund (1966).

The author has collected a large material of brown crustaceous algae from the Öresund. This material has not yet been fully worked out, but the author has had great difficulty in distinguishing sharp boundaries in the material which could justify a separation into different taxa. Transitional stages exist which vary with age, depth and season. The author is, therefore, bound to share Ravan-

ko's (1970 b) opinion: "I am inclined to believe that *Lithoderma fatiscens* Aresch., *Lithoderma rosenvingii* Waern, *Lithoderma fatiscens* Aresch. emend Kuck., *Lithoderma subextensum* Waern, *Sorapion kjellmanii* (Wille) Rosenv., *Sorapion simulans* Kuck., *Ralfsia ovata* Rosenv. and *Petroderma maculiforme* (Wollny) Kuck. belong to the same species, --- *Lithoderma fatiscens* Aresch., which is the first combination used". The author's material will later be carefully reexamined in combination with culture experiments. For the time being the author regards all lithodermoid crusts as *Lithoderma fatiscens* Aresch. s.l.

Lithoderma fatiscens s.l. is found in great abundance from 1 - 20 - (25) m in depth on rocks and stones of different size during the whole year. Fertile specimens are found from November to April.

Localities: Common in the whole area.

Polyhalobe pleioeuryhaline.

Ralfsia bornetii Kuck.

Distribution Sweden: Bohuslän, Kristineberg, Kylin (1947).

Denmark: N. and middle Kattegatt, Great Belt, Smålandshavet, Öresund.

This species has been found on a few occasions in very limited numbers at very exposed localities. It grows in the littoral zone and the lowest part of the supralittoral up to 0.5 m above the 0-line on stones, often together with *Ralfsia verrucosa*. One find was made in a rock-pool 6 m above the 0-line, together with *Chordaria flagelliformis*, *Dumontia incrassata*, *Fucus serratus* and *Fucus vesiculosus*.

The filaments vary in thickness from 6 - 12 μ and the cells are almost quadrangular, the paraphyses varying in length from 100 - 200 μ . Only unilocular sporangia, 18 - 24 x 80 - 100 μ , have been found.

Locality: Kullen.

Polyhalobe mesoeuryhaline.

Ralfsia clavata (Harv. in Hook.) Crouan frat.

(*Ralfsia tenuis* Kylin)

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Kullen, Levring (1935).

Denmark: Little Belt, Smålandshavet, Öresund.

The nomenclature of this species is somewhat dubious, cf. Kylin (loc.cit.) and Jaasund (1965). The author has preferred to use the nomenclature of Dixon & Parke (1968). Wynne (1969) has established a connection between a *Ralfsia*-like crust and *Petalonia fascia*. He identifies the crust with *Ralfsia californica* Setch. et Gardn. Edelstein, Chen & Mc Lachlan (1968) reported the complete life-cycle of *Petalonia fascia* as including an alternation with *Ralfsia clavata* (Harv.) Crouan. Though no investigations of the life-cycle of the Scandinavian *Petalonia fascia* have been made, it is likely that, here too, the life-cycle is complete.

The author has found small, thin *Ralfsia* crusts which have been referred to *Ralfsia clavata* (Harv. in Hook.) Crouan frat. *Ralfsia clavata* seems to be rather common in the north part of the area but is also frequently found in the central part. It grows from 0 - 15 - (20) m in depth on stones but most abundantly on dead mollusc shells, such as *Cardium*, *Mya*, *Mytilus* and on balanids.

The crusts are generally 2 - 8 mm in diameter, 3 - 5 cells thick, light-brown, very firmly attached to the substratum. It is found throughout the year.

Unilocular sporangia, $18 - 26 \times 50 - 65 \mu$, have been found but no plurilocular sporangia.

Localities: Hovs Hallar, Hallands Väderö, Kullen, W. Lerhamn, Gilleleje, Grållegrund, Staffansbank, Saltholm flack.

Polyhalobe mesoeuryhaline.

Ralfsia lucida Lund

Distribution Sweden: -

Denmark: Helsingör, Lund (1967).

This species was described by Lund (loc.cit.) from material collected near the sewage outlet of Helsingör. The author has only been able to find it at some localities near Helsingör from 1 - 2 m in depth.

Localities: Helsingör (north harbour, Kronborg, south harbour).

Polyhalobe mesoeuryhaline.

Ralfsia verrucosa (Aresch.) J. Ag.

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Kullen, Levring (1935); Blekinge, Levring (1940).

Denmark: Kattegatt, Great Belt, Smålandshavet, W. Baltic; Copenhagen, Ørsted (1844).

Ralfsia verrucosa is abundant in the north part of Öresund. There is a marked decreasing tendency in the abundance towards the south parts of the area. South of Barsebäck the species is only found occasionally. *Ralfsia verrucosa* grows most abundantly and is best developed at exposed localities in rock-pools up to 6 m above the 0-line. It is also found in the littoral and sublittoral zone down to 6 m in depth, though below 1 m it is poorly developed. It grows on cliffs, stones and more seldom on *Mytilus* shells.

Ralfsia verrucosa forms light brown to light grey-brown crusts, varying in size from about 1 - 100 cm². The crusts vary in thickness from 50 μ to about 2 mm. The peripheral part seems to be a little more thicker than the more central part. The thick old crust always consists of some three or four layers of new generations. All specimens, particularly the old ones, are loosely attached to the substratum. *Ralfsia verrucosa* is found throughout the year. Unilocular sporangia have been seen in all seasons but most frequently from May to November. Like Kylin (loc.cit.) the author has not observed plurilocular sporangia.

Localities: Hovs Hallar, Hallands Väderö, Kullen, Mölle, Lerhamn, Gilleleje, Helsingör, Barsebäck, Bredgrund, Skanör, the canal of Falsterbo.

Polyhalobe pleioeuryhaline.

Myrionemataceae

Entonema effusum Kylin

(*Streblonema effusum* Kylin)

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Kullen, Levring (1935); Blekinge, Levring (1940).

Denmark: N. Kattegatt, Smålandshavet.

Levring (1935) writes, "Diese Art kommt nicht selten endophytisch in *Ceramium* sp. vor". The author has examined a very large material microscopically in order to find different epiphytes and endophytes, but has not been able to find any *Entonema effusum* except on two occasions in the north part of the area from 2 - 4 m in depth. In both cases the cortical bands of a few specimens of *Ceramium strictum* s.l. were more or less covered with *Entonema effusum*. The specimens were collected in August and September and rich in well-developed, mature plurilocular sporangia, (10) - 12 - 20 x 26 - (60) μ , of which some were empty.

Localities: Kullen, Grållegrund.

Polyhalobe pleioeuryhaline.

Entonema oligosporum (Strömf.) Kylin

(*Streblonema oligosporum* Strömf.)

Distribution Sweden: Kullen, Levring (1935); Blekinge, Levring (1940); Öregrund, Waern (1952).

Denmark: -

Jaasund (1965) is of the opinion that *Entonema oligosporum* is perhaps only a transitional stage of other brown algae. This might be true, considering the great variation in Waern's (loc.cit.) material from Öregrund and Ravanko's (1970 a) observations in her cultures.

Of this little endophytic brown alga which seems to be common in the Baltic, Levring (1940) remarks, "ohne Zweifel die gewöhnlichste aller vorkommenden mikroskopischen Endo- und Epiphyten". The author has only made two finds of the species at Kullen from 15 - 20 m in depth, growing in *Polysiphonia elongata* and *Polysiphonia nigrescens*, collected in March. Judging from the distribution *Entonema oligosporum* could belong to the Baltic relict flora.

The filaments were creeping under the cortex cells in *Polysiphonia elongata* and under the pericentral cells in *Polysiphonia nigrescens*. A few hairs, 3 - 6 μ broad, were noticed. The cells were 4 - 8 x 15 - 25 μ . The uniseriate plurilocular sporangia were 6 - 10 x 20 - 30 μ ; no unilocular sporangia were found.

Locality: Kullen.

Polyhalobe pleioeuryhaline.

Hecatonema diffusum Kylin

Distribution Sweden: Bohuslän, Koster, Kristineberg, Kylin (1907); Kullen, Levring (1935).

Denmark: -

The validity of this species is uncertain as it could very well be conspecific to *Protectocarpus speciosus* (Börg.) Kuck.

This alga seems to have been overlooked along the Swedish coast. Levring (loc.cit.) writes, "Ich habe sie nur einmal im Mai angetroffen". However, the species seems not too uncommon. It grows from 0 - 1 m in depth on different algae, e.g. *Chondrus crispus*, *Petalonia fascia* and *Petalonia zosterifolia* and sometimes on *Zostera* leaves, where it is seen as small brown spots, about 0.5 - 2 mm in diameter. The filaments are 80 - 100 μ long with cells 8 - 11 μ broad. Hairs are not uncommon. Most filaments are unbranched. The species is found during early spring in February and March with plurilocular sporangia 10 - 12 x 12 - 50 μ .

Localities: Hallands Väderö, Kullen, Skogshoved, Barsebäck.

Polyhalobe mesoeuryhaline.

Hecatonema reptans (Reinke) Sauv.

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Kullen, Levring (1935); Blekinge, Levring (1940).

Denmark: -

This little epiphytic alga has been found on a few occasions in the Öresund, growing from 0 - 5 m in depth on *Ectocarpus* sp. and *Petalonia fasciata*. The thalli were about 75 - 130 μ high and the cells 6 - 9 x 10 - 16 μ . The species is found from February to May. In February the plurilocular sporangia had just begun to be developed; in May they were fully developed, 10 - 12 x 30 - 40 μ .

Localities: Kullen, W. Helsingborg, Bredgrund.

Polyhalobe pleioeuryhaline.

Leptonematella fasciculata (Reinke) Silva

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Kullen, Levring (1935); Blekinge, Levring (1940); Gotland, Svedelius (1901).

Denmark: Kattegatt, Samsö, The Belts, Öresund, W. Baltic.

This epiphytic brown alga is abundantly found in the north part, frequently in the central and sparsely in the south from 0.5 - 10 m in depth. It is, however, most abundant from 0.5 - 1.5 m and below 1.5 m it is only found occasionally. It grows abundantly on *Ascophyllum nodosum* (note that this species has its south border at Kullen) and frequently on *Fucus serratus* and *Fucus vesiculosus*, now and then also on red algae and mollusc shells.

The growth seems to culminate in May and June. The filaments are about 2 mm long, the cells 8 - 12 μ broad and 1 - 2 - (3) times as long. In Jaasund's (1965) material from north Norway the cells were 13 - 15 μ broad. Kylin (loc.cit.) reports the cell breadth as 10 - 15 μ and a filament length of 3 mm from Bohuslän. The species has been found from February to October. Unilocular sporangia, 10 - 15 x 20 - 25 μ , are found in May and the beginning of June, plurilocular sporangia in low numbers from June to August.

Localities: Hovs Hallar, Hallands Väderö, Kullen, Gilleleje, Helsingör, Ven, Barsebäck, Tuborg, Klagshamn.

Polyhalobe pleioeuryhaline.

Microspongium gelatinosum Reinke

Distribution Sweden: Bohuslän, Koster, Kristineberg and Halland, Råö, Kylin (1947); Kullen, Levring (1935).

Denmark: Great Belt; Öresund, Lund (1966).

Lund (loc.cit.) has shown that *Scytosiphon lomentaria* in its life-cycle has a microscopic sporophyte stage which he with some hesitation has identified as *Microspongium gelatinosum*. From Japan, however, Tatewaki (1966) reports a *Ralfsia*-like sporophyte stage of *Scytosiphon lomentaria*.

Microspongium gelatinosum shows a remarkable change in abundance from one year to another. Some years it is very common and other years it can hardly be

found. For instance during 1965 and 1968 the species was very common. In the Öresund the species grows from 1 - 2 m in depth on *Fucus serratus* as 1 - 3 mm small cushions, while Lund (loc.cit.) found it on stones. The first specimens are seen in June and the species can be found to the end of October. Individuals with plurilocular sporangia are seen from June to October.

Localities: Hallands Väderö, Kullen, Lerhamn, Viken, Gilleleje, Råå, Skogshoved, Lomma, Skanör.

Polyhalobe mesoeuryhaline.

Microspongium globosum Reinke

Distribution Sweden: Bohuslän, Kristineberg, Kylin (1947); Kullen, Levring (1935); Blekinge, Levring (1940); Gotland, Svedelius (1901).

Denmark: S. Kattegatt, Little Belt; Copenhagen, Kristiansen (1960).

As stated below, Jaasund (1965) suspected that *Microspongium globosum* was the final stage of *Myrionema corunnae* and that these two species were a part of the *Ectocarpus fasciculatus* complex. The author is of the opinion that these suspicions may be justified.

The distribution of the species in Scandinavian waters is insufficiently known; it may be common but easily overlooked. In the Öresund area it is common at Kullen at exposed localities from 0 - 1 m in depth and in low-lying rock-pools. Kylin (loc.cit.) and Levring (loc.cit.) have both observed the species on thread-like algae, but the author has with few exceptions come across the species growing on *Ahnfeltia plicata*, *Chondrus crispus* and *Furcellaria fastigiata*. The filaments are about 1 mm long and 6 - 9 μ in diameter. The species is found from February to April with uniseriate plurilocular sporangia 8 - 11 μ broad and (15) - 20 - 45 μ long.

Locality: Kullen.

Polyhalobe pleioeuryhaline.

Myrionema corunnae Sauv.

Distribution Sweden: Bohuslän, Koster, Väderöarna, Kristineberg, Kylin (1947).

Denmark: -

As mentioned many scientists, e.g. Jaasund (1961, 1965), Ravanko (1970 a), Baker & Evans (1971) and Clayton (1972) have expressed opinions that i.a. *Myrionema corunnae* could possibly be linked to the life-cycle of *Ectocarpus fasciculatus*. The situation is rather confused as Clayton (loc.cit.) is bound to interpret these findings as contaminants in the cultures. Jaasund (1965) further concludes from his field observations that *Myrionema corunnae* and *Microspongium globosum*, which occur together in collections from Risöy, could be conspecific and a developmental stage of *Myrionema corunnae*. Judging from Kylin's (loc.cit.) observation that *Microspongium globosum* "--- kommt nur im Frühling vor. Fertil im März und April" and *Myrionema corunnae* is "fertil im Juni und August", Jaasund's theory could not hold true. However, the author has found fertile specimens of both species during March and April. Further, the author has found *Microspongium globosum* and *Myrionema corunnae* in spring and *Ectocarpus fasciculatus* during autumn growing on *Ahnfeltia plicata*. These observations support Jaasund's (loc.cit.) statement. The only way to finally solve this problem is by culture experiments over a long period of time and perhaps more important combined with cytological investigations.

Myrionema corunnae is probably not uncommon in the north part of Öresund

but is easily overlooked. It has been recorded at Kullen at very exposed localities in the littoral zone and in low-lying rock-pools on *Ahnfeltia plicata* and *Chondrus crispus*. The cushions were about 1 mm in diameter; the filaments measured 3 - 5 μ broad and consisted of 3 - 5 cells. The species is only found in March and April with uniseriate plurilocular sporangia, 3 - 5 cells long.

Localities: Hallands Väderö, Kullen.

Polyhalobe meioeuryhaline.

Myrionema magnusii (Sauv.) Lois.

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Kullen, Levring (1935); Blekinge, Levring (1940); Gotland, Svedelius (1901); Öregrund, Waern (1952).

Denmark: N. Kattegatt, Smålandshavet.

This little alga which seems to be an obligate epiphyte on *Zostera* leaves was mentioned by Levring (1935) as "nicht selten epiphytisch auf alten *Zostera*-Blättern". Though, as stated elsewhere, a large material of the host has been examined, comparatively few finds of *Myrionema magnusii* have been made. The species is found sparsely from 1 - 10 - (15) m in depth. The filaments are usually 4 - 7 μ broad and 20 - 35 μ long. It is found throughout the year with plurilocular sporangia from March to November.

Localities: Mölle, Dronningmölle, Helsingborg, Råå, Ven, Landskrona, Sjöboheden, Barsebäck, Skanör.

Polyhalobe pleioeuryhaline.

Myrionema strangulans Grev.

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Kullen, Levring (1935); Blekinge, Levring (1940).

Denmark: N. Kattegatt.

Simmons (1898) has recorded the species on *Porphyra umbilicalis* from Kullen. Levring (1935) writes, "ich habe sie einigemal im August und September angetroffen". *Myrionema strangulans* has been found on three occasions in the Öresund from 0.5 - 2 m in depth growing on *Ceramium rubrum* and *Furcellaria fastigiata*. In contrast to Kylin (loc.cit.) and Levring (1935) the finds were made in April. The specimens bore plurilocular sporangia.

Localities: Kullen, Ven.

Polyhalobe pleioeuryhaline.

Elachistaceae

Elachista fucicola (Vell.) Aresch.

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Kullen, Levring (1935); Blekinge, Levring (1940); Öregrund, Waern (1952).

Denmark: All districts.

Elachista fucicola is a very common epiphyte in the Öresund area, best developed at semi-exposed localities. It grows from the 0-line down to 5 - 6 m.

depth but most frequently from 0 - 1.5 m on *Fucus serratus* and *Fucus vesiculosus* and to a much lesser extent on *Ascophyllum nodosum* and *Fucus distichus* ssp. *edentatus*.

The filaments are 20 - 40 μ thick and about 10 - 15 mm long. Small specimens are found in February and maximum size is reached in April and May. Due to mechanical wear the assimilating filaments are gradually torn away. By the end of June the naked parenchymatous basal part can already be seen. Near the base of the filaments unilocular sporangia, about 25 - 35 x 60 - 90 - (100) μ , have been noticed from May to November. They seem to be a little smaller than in north Norway, where Jaasund (1965) reports 35 - 170 μ . No plurilocular sporangia have been met with, though Kornmann (1962) observed these organs in culture.

Localities: Common in the whole area.

Polyhalobe pleioeuryhaline.

Corynophlaeaceae

Leathesia difformis (L.) Aresch.

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Kullen, Levring (1935); Blekinge, Levring (1940); Trosa archipelago, Wallentinus (1969); Åland, Waern (1952).

Denmark: All districts.

Leathesia difformis is infrequently found in the Öresund area. Some years it is rather common and other years only few specimens are to be found. Levring (1935) found it to be "selten" at Kullen. The species is most conspicuous in the north part, though it is widespread in the Baltic and has only been seen in low numbers in the south part. It grows at exposed to semi-exposed localities from 0.25 - 1 - (2) m below the 0-line, mainly on *Ahnfeltia plicata* and more seldom on *Chordaria flagelliformis* and old *Zostera* leaves. On a few occasions it has also been found growing on rocks. Sometimes *Leathesia difformis* can be covered by *Acrochaetium collopodum*.

This hollow, sphaerical or irregularly shaped sponge-like alga is reported by Jaasund (1965) to become 2 - 7 cm in diameter. Kylin (loc.cit.) reports the diameter of the Swedish material to be 0.5 - 5 cm. The diameter of the Öresund material varies between 5 - 7 - (10) mm. The first sign of the alga is found at the end of April and the maximum number and size are normally attained by last part of June. The alga then rapidly decays and in August no finds have been made. Unilocular sporangia are frequently found in May to June, varying from 13 - 17 x 18 - 22 μ . Plurilocular sporangia, 3 - 4 x 18 - 20 μ , have been found only on a few occasions.

Localities: Hallands Väderö, Kullen, Lerhamn, Gilleleje, Helsingör, Ven, Barsebäck, Limhamn.

Polyhalobe pleioeuryhaline.

Myriactula fucorum (Rosenv.) Kylin

Distribution Sweden: Bohuslän, Kristineberg, Kylin (1947).

Denmark: Öresund (Saltholm), Rosenvinge & Lund (1943).

This tiny epiphyte on *Fucus* species may be common and widespread but is apparently overlooked due to its choice of habitat. It has been found on a very

few occasions in the Öresund, growing in the cryptostomata of *Fucus serratus* and *Fucus vesiculosus* from April to August. Only plurilocular sporangia have been noticed.

Localities: Kullen, Helsingör, Barsebäck.

Polyhalobe mesoeuryhaline.

Chordariaceae

Chordaria flagelliformis (O.F. Müll.) C. Ag.

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Kullen, Levring (1935).

Denmark: All districts except Smålandshavet and Baltic Möen.

This species is common in the north part of the Öresund where it at exposed or semi-exposed localities forms a dense but narrow belt between the *Fucus vesiculosus* and *Fucus serratus* belts, about 20 - 30 cm below the 0-line. Very occasionally it has been seen epiphytic on *Fucus* sp. At very exposed localities at Kullen some specimens of *Chordaria flagelliformis* can be found growing in rock-pools up to 6 m above the 0-line. South of Helsingborg the species does no longer form a distinct belt but is found as patches at suitable localities. South of the island of Ven the species is frequently seen but only as single specimens.

As a rule the plants are about 1 mm thick and 20 - 30 cm long. At localities which are very exposed or have a high concentration of nutrients it can reach a length of over 50 cm. *Chordaria flagelliformis* starts growing in March and reaches full length in the beginning of June. During spring the specimens are densely covered with assimilating filaments which are almost torn away in June. The number of specimens gradually reduces during winter and the last old *Chordaria* plants are usually seen in March. Unilocular sporangia, 16 - 20 x 30 - 40 μ , have been found from June to December.

Caram (1955) reported a life-cycle of *Chordaria flagelliformis* and a streblonemoid epiphyte. Jaasund (1965) is of the same opinion and considered this epiphyte to be conspecific with *Streblonema chordariae* (Wollny) Kuck. The author has not been able to find this stage in the Öresund material.

Localities: Belt-forming: common in the north part.

Single specimens: Barsebäck, Vikhög, Tuborg, Dragör, Limhamn, Skanör.

Polyhalobe mesoeuryhaline.

Eudesme virescens (Carm. ex Harv. in Hook.) J. Ag.

Distribution Sweden: Bohuslän, "gemein bis spärlich" and Halland, "spärlich bis selten", Kylin (1947); Kullen, "ziemlich selten", Levring (1935); Blekinge and Stockholm, Levring (1940).

Denmark: All districts.

This alga was up till a few years ago a conspicuous part of the spring algal vegetation except in the north part of the area where it was less abundantly seen. Since 1969 very few specimens have been met with. *Eudesme virescens* grew at sheltered to semi-exposed localities from 0 - 3 m in depth, mainly on *Zostera* leaves and more seldom on *Fucus serratus* and *Fucus vesiculosus*. In a few cases it has also been observed growing on stones. In shallow, sandy bays in the middle and south parts of the area the *Zostera* leaves could be more or less covered with *Eudesme virescens*.

The length of the thalli varies between 3 - 12 - (14) cm. The alga was first

seen in April and was most conspicuous in May and the first part of June when most specimens began to decay. A few finds have been made in July but none in August. Unilocular sporangia, 20 - 35 x 40 - 70 μ , have been found in May and June. Plurilocular sporangia have not been observed.

Localities: Hallands Väderö, Kullen, Lerhamn, Viken, Gilleleje, Hornbaek, Helsingborg, Råå, Ålabodarna, Ven, Taarbaek, Barsebäck, Vikhög, Dragör, Limhamn, Klagshamn, Skanör.

Polyhalobe pleioeuryhaline.

Sphaerotrichia divaricata (C. Ag.) Kylin

Distribution Sweden: Bohuslän, Kylin (1947).

Denmark: All districts except the Baltic proper.

This species has not been found in the Öresund area by the present author. There is one observation from Helsingör, Rosenvinge & Lund (1943) and in the Botanical Museum in Lund there are some specimens collected by Hylmö near Ven from 10 - 15 m in depth.

Locality: -

Polyhalobe mesoeuryhaline.

Spermatochneaceae

Spermatochneus paradoxus (Roth) Kütz.

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Kullen, Levring (1935); S. Öresund, Lönnberg (1898).

Denmark: All districts except Bornholm.

According to Lönnberg (1898) this species was abundantly seen in the Öresund. This is confirmed by herbarium specimens at the Botanical Museum in Lund. Hylmö and Sjöstedt have collected the species from many localities in the central and south part of the Öresund. It was very conspicuous near Malmö during the 1930s according to Levring (personal communication).

The distribution of *Spermatochneus paradoxus* has apparently changed drastically during later decades, as the author only has been able to find it twice: one find near Mölle from 5 m in depth in June 1966 and another find at Saltholm near Copenhagen in the *Fucus* belt in September the same year.

Localities: Mölle, Saltholm.

Herbarium specimens from Hylmö and other collections at the Botanical Museum, Lund: Barsebäck, Bjärred, Sjöllen, Malmö, Limhamn, Bunkeflo-Klagshamn, Skanör.

Polyhalobe mesoeuryhaline.

Stilophora rhizodes (Turn.) J. Ag.

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Kullen, Levring (1935).

Denmark: All districts except the Baltic proper.

Levring (loc.cit.) writes about this species, "kommt in dem ganzen Gebiet

ziemlich gemein vor". Judging from herbarium specimens in the Botanical Museum in Lund and the review by Rosenvinge & Lund (1943) there are several finds from the middle and south parts of the Öresund.

The author, however, has only been able to find the species in very limited numbers in the north part of the area. It has been found from 0.2 - 7 m in depth growing on *Fucus serratus* and *Fucus vesiculosus* and on stones. The specimens have been 7 - 10 cm long. The major part of the material has been found in July to September. Unilocular sporangia seem to be rare; only a few measurements are available: 9 - 12 x 30 - 40 μ .

Localities: Kullen, Grållegrund.

Herbarium material: Helsingör (Rasch); Tre Kroner, Copenhagen (Rasch); Saltholm (Lund); Malmö, Foteviken (Sjöstedt); Foteviken, Køge (Simmons).

Polyhalobe mesoeuryhaline.

There are some finds of *Halorhiza vaga* Kütz. by Levring (1935) from Öresund at Kullen, growing at *Fucus* sp. and near Malmö, loose-lying, collected by Dr Cederholm. The author has also with some hesitation interpreted some *Fucus* epiphytes as *Stilophora tuberculosa* (Hornem.) Reinke. The author is of the opinion that the differences between these two taxa and *Stilophora rhizodes* are too vague to separate them. This problem must be solved by further investigations including culture studies.

DICTYOSIPHONALES

Myriotrichiaceae

Myriotrichia clavaeformis Harv.

Distribution Sweden: Bohuslän and N. Halland (*Myriotrichia filiformis* Harv.), Kylin (1947).

Denmark: Kattegatt, Samsø (*Myriotrichia clavaeformis*).

The taxonomic status of *Myriotrichia filiformis* Harv. and *Myriotrichia clavaeformis* Harv. has for a long time been disputable. Rosenvinge & Lund (1947) have summed up the discussion and state that *Myriotrichia filiformis* is a stage in the development of *Myriotrichia clavaeformis*. Jaasund (1965), however, treats them as separate species.

Myriotrichia clavaeformis is found more or less frequently in the north part of the Öresund area at sheltered localities from the 0-line down to 20 cm in depth and in low-lying rock-pools on *Scytosiphon lomentaria*. The species grows as an epiphyte, forming 5 - 12 mm long tufts, more or less covering old specimens of the host. These "tufts" consist of creeping filaments with upright, unbranched, polysiphonous shoots which tend to be monosiphonous in the upper parts. The species appears every year in June. Unilocular sporangia, 30 - 40 μ i diameter, are born at the base of short shoots; only a few plurilocular sporangia have been found.

Localities: Halland: Lerö, Kullen, Mölle, Lerhamn, Höganäs, Gilleleje.

Polyhalobe mesoeuryhaline.

Myriotrichia repens Hauck

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Kullen, Levring (1935); Öregrund, Waern (1952).

Denmark: N. Kattegatt.

When examining the epiphytes on *Chorda filum* the author has a few times observed creeping filaments with upright shoots, bearing unilocular sporangia. These have been interpreted as *Myriotrichia repens*. The host was collected at Kullen at sheltered localities from 1 m in depth in June and August.

Locality: Kullen.

Polyhalobe pleioeuryhaline.

Tilopteridaceae

Pilayella

According to Kylin (1933 b, 1937 b, 1947) two distinct species of *Pilayella* are found in Swedish waters: *Pilayella littoralis* (Lyngb.) Kjellm. and *Pilayella rupincola* (Aresch.) Kylin. Kylin (loc.cit.) separated the species on the following grounds:

1. The mainly epilithic growth of *Pilayella rupincola* and epiphytic growth of *Pilayella littoralis*.
2. The difference in size: *Pilayella rupincola*, below 5 cm, and *Pilayella littoralis* larger, 10 - 40 cm.
3. Difference in life-cycle: *Pilayella rupincola* has no alternation of generations (only a sporophytic stage is known). *Pilayella littoralis* has a regular isomorphic alternation of generations.

Whether these grounds are relevant for separating the material into two species has been discussed by different authors for a long time, e.g. Levring (1940), Rosenvinge & Lund (1941) and Jaasund (1965). Russell (1963) who studies cultures of the different species, could not find any difference between them and suggested that the name *Pilayella rupincola* should be abandoned. According to West (1967) material of *Pilayella littoralis* and *Pilayella rupincola* from the American west-coast showed differences in their life-cycles. He is also of the opinion that Russell's culture material did not consist of the real *Pilayella rupincola*.

For the time being the author is bound to follow Kylin's (loc.cit.) opinion when considering the differences in life-cycle and ecology, until further investigations of the Swedish material including cytological studies have been made.

Pilayella littoralis (L.) Kjellm.

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Kullen, Levring (1935); Hällviken, Lönnberg (1899).

Denmark: All districts (*P. littoralis* s.l.).

This species is common in the whole area. It grows from 0 - 2 m in depth mainly as an epiphyte on fucoids but it is also found loose in large amounts from 5 - 15 m in depth. The length of the thalli varies from 5 - 20 cm. In the attached state the species is found throughout the year but is most well developed from April to July and from September to October. The loose specimens are especially common from April to July. Unilocular sporangia have been found all the year round and in association with plurilocular sporangia on the same plant regularly from April to July and occasionally in November to February.

Localities: Common in the whole area.

Polyhalobe pleioeuryhaline.

Pilayella rupincola (Aresch.) Kylin

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Kullen, Levring (1935); Blekinge, Levring (1940); Öregrund, Waern (1952).

Denmark: -

Pilayella rupincola forms mainly at exposed localities a dense belt around the 0-line. The breadth of the belt depends on the degree of exposure. At very exposed localities the belt can be found from 0.75 m above the 0-line to 1 m below. In the south part of the area the species is found from 0.5 - 1 m in depth. *Pilayella rupincola* is in most cases only found epilithically.

The plants are 3 - 5 cm long and sometimes with marked "cable rolling". Growth begins in December and mainly takes place from February to May. At the end of June the main part of the *Pilayella rupincola* vegetation begins to decay. Some years, however, some specimens can survive in the littoral and sublittoral zone and a second growth maximum can then be found in September and October. Plurilocular sporangia together with unilocular occur on the same plant, though the unilocular sporangia always seem to be in the majority. Sporangia have been found from February to October.

Localities: Common in the whole area.

Polyhalobe pleioeuryhaline.

Punctariaceae

Desmotrichum undulatum (J. Ag.) Reinke

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Kullen, Levring (1935); Tvärminne, Skottsberg (1911).

Denmark: All districts except Bornholm.

According to Kylin (1907) four species of *Desmotrichum* are found along the Swedish west-coast, namely *Desmotrichum balticum* (Kütz.) Reinke, *Desmotrichum repens* Kylin, *Desmotrichum scopulorum* Reinke and *Desmotrichum undulatum* (J. Ag.) Reinke. Later Kylin (1947) was of the opinion that *Desmotrichum balticum* and *Desmotrichum scopulorum* were conspecific and that *Desmotrichum balticum* could be a stage of *Desmotrichum undulatum*. But for the time being he kept *Desmotrichum balticum* and *Desmotrichum undulatum* as separate species. Rosenvinge & Lund (1947) considered all taxa as different developmental stages of one species, *Desmotrichum undulatum*. Jaasund (1965) states, "it is considered beyond doubt that *Entonema effusum* Kylin belongs to *Desmotrichum undulatum* Reinke, --- *Streblonema parasiticum* Sauv. recorded in West Norway is believed to be a *Desmotrichum undulatum* stage, but not *D. scopulorum*". After working through the material from the Öresund the author is bound to follow Rosenvinge & Lund's (loc.cit.) opinion. As said before, the material of *Entonema effusum* from the Öresund is scarce which makes it difficult to support Jaasund's (loc.cit.) statement.

The appearance of *Desmotrichum undulatum* in the undulatum stage is very irregular. Some years, e.g. 1966 and 1970, the stage was conspicuous and found from 0.5 - 3 m in depth on almost every examined *Zostera* leaf and also on *Chorda filum*. Other years it is uncommon and even rare. Most of the thalli were about 5 cm long and 0.5 cm broad. A minor part of the material measured up to 10 cm in length. The undulatum stage is only found in April to middle of July. No unilocular sporangia have been met with but plurilocular sporangia, 30 - 50 μ long and 12 - 30 μ in diameter, are frequently found, in most cases in groups in the upper parts of the thallus. Sometimes they are irregularly shaped and flattened.

The balticum stage is frequently seen but always in low numbers. It grows mainly in the littoral zone from 0 - 2 m in depth on *Zostera* leaves but also on

Ceramium rubrum, *Ceramium strictum* s.l., *Chorda filum* and *Fucus serratus*. One find was made from 6 m in depth. On one occasion it was also found growing on stone or at least intermingled with *Calothrix* sp. from the littoral zone. The erect shoots of this stage varied from 1 - 3 mm in length. The balticum stage is found from April to October. Plurilocular sporangia are common during the whole period.

Localities: Common in the whole area.

Polyhalobe mesoeuryhaline (*Desmotrichum undulatum* stage).

Polyhalobe pleioeuryhaline (*Desmotrichum balticum* stage).

Litosiphon pusillus (Carm. ex Hook.) Harv.

Distribution Sweden: Bohuslän and N. Halland, Kylin (1947).

Denmark: N. and S. Kattegatt, Samsö, The Belts, Öresund (one find from Hellebaek).

This species which is widely distributed in the north part of Kattegatt has only been recorded a few times in the south part of Kattegatt. In the Öresund Rosenvinge & Lund (1947) mention one find 'north' of Helsingör.

The present author has found *Litosiphon pusillus* twice: once near Helsingborg growing on *Zostera* leaves (!) in the beginning of May. These specimens were about 3 cm long and sterile. The second find was made at Kullen from 1 m in depth on *Chorda filum* in September. On this occasion a large part of several *Chorda* thalli was more or less overgrown with *Litosiphon pusillus*. The specimens varied in length from 4 - 6 cm, were (85) - 90 - 130 μ broad and bore rounded unilocular sporangia, 12 - 18 μ in diameter.

Localities: Kullen, Helsingborg.

Polyhalobe meioeuryhaline.

Punctaria plantaginea (Roth) Grev.

Distribution Sweden: Bohuslän and N. Halland, Kylin (1947); Kullen and Ven, Hylmö (unpublished).

Denmark: N. and S. Kattegatt, Samsö, Little Belt.

This species is very rare at Kullen. Hylmö in his unpublished papers recorded two finds from the Öresund, one at Kullen from July 1916 and the other near Ven at a depth of 10 m. The author has found some specimens of *Punctaria plantaginea* growing at Kullen at very exposed localities about 0.2 m below the 0-line on *Ahnfeltia plicata*. In April they were about 5 cm long and 4 mm broad, most of the "hair-tufts" had been shed; a few underdeveloped unilocular sporangia could be seen.

Locality: Kullen.

Material in the herbarium at the Botanical Museum, Lund: Kullen and Ven (Hylmö).

Polyhalobe meioeuryhaline.

Dictyosiphonaceae

Dictyosiphon chordaria Aresch.

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Kullen, Levring (1935); Blekinge, Levring (1940); Öregrund, Waern (1952).

Denmark: S. Kattegatt, Samsö, The Belts, Smålandshavet, W. Baltic, Bornholm.

In Hylmö's collection (at the Botanical Museum, Lund) there are some specimens of *Dictyosiphon mesogloia* Aresch. from the vicinity of Ven and some of *Gobiosiphonia baltica* (Gobi) Reinke, collected near Malmö. Concerning the distribution of *Dictyosiphon chordaria* it seems to belong to the group of relict flora of the Baltic.

The author has only found the species once in the Öresund growing from 5 - 7 m in depth on stones. Most of the other Swedish finds seem to be collected from 0 - 1 m in depth. The specimens were 5 - 7 cm long and sparsely branched. The find was made in May.

Locality: Bredgrund.

Polyhalobe pleioeuryhaline.

Dictyosiphon foeniculaceus (Huds.) Grev.

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Kullen, Levring (1935); Blekinge, Levring (1940); Öregrund, Waern (1952).

Denmark: All districts.

The species is common in the whole area. It grows at sheltered to semi-exposed localities from 0 - 1 - (2) m in depth, often on *Chordaria flagelliformis*, *Fucus serratus* and *Fucus vesiculosus*. The thalli are about 1 mm thick near the holdfast, 20 - 50 cm long and heavily branched. The first individuals are seen in the middle of May. They reach their full development in July and August. Most specimens seem to decay in August and September. Unilocular sporangia, about 25 - 38 μ in diameter, are met with from the middle of June to September.

Localities: Common in the whole area.

Polyhalobe pleioeuryhaline.

SCYTOSIPHONALES

Scytosiphonaceae

Petalonia fascia (O.F. Müll.) Kuntze

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Kullen, Levring (1935).

Denmark: All districts except Smålandshavet and the Baltic.

Wynne (1969) has shown that *Petalonia fascia* has a heteromorphic life-cycle with an alternation between the *Petalonia* stage and a *Ralfsia* stage.

According to Kylin (loc.cit.) *Petalonia fascia* is "spärlich bis selten -- einjährig, fertil im April bis August". Levring (loc.cit.) "nur bei einer Gelegenheit Mitte März angetroffen". It is not unlikely that *Petalonia fascia* has become more common during the last ten years. During 1960 - 1962 single specimens were observed at Kullen. Now *Petalonia fascia* forms a dense belt from Kullen to Helsingborg and at Ven, but between Helsingborg and Landskrona the distribution of the

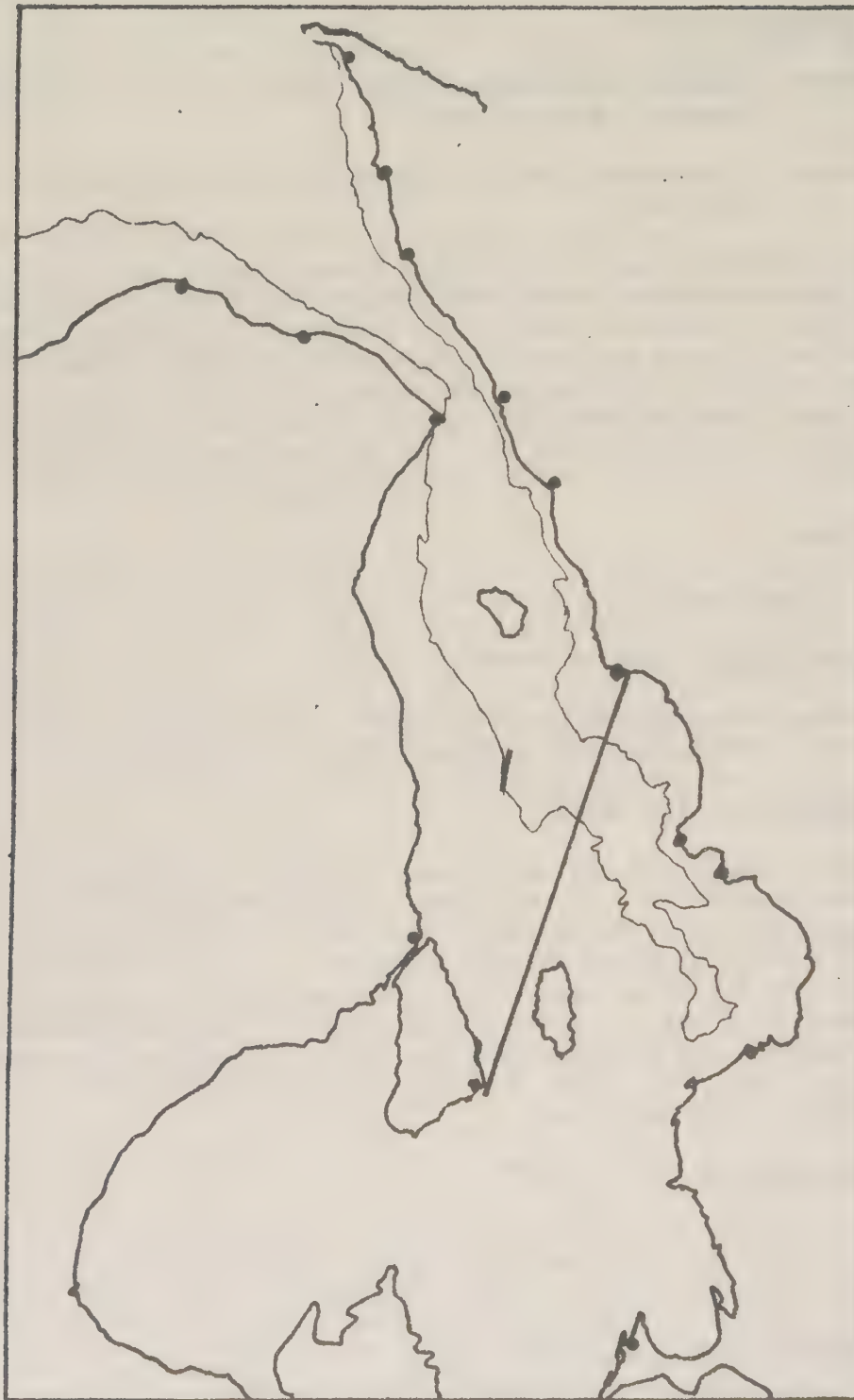


Fig. 102. The south border of *Petalonia fascia* and *Petalonia zosterifolia*.

species is rather sparse. In the Danish coast it is abundant down to the south border at Dragør (Fig. 102). From August to March *Petalonia fascia* grows at semi-exposed to exposed localities in a belt from the 0-line down to 0.2 m below. During summer specimens are sparsely found around the border between the littoral and sublittoral zone. (Fig. 103)

The observed specimens are as a rule 10 - 15 cm long and 5 - 10 mm broad. At exposed localities the thallus are often somewhat longer, 15 - 18 cm, 4 - 6 mm broad and heavily twisted. At eutrophicated localities forms up to 30 cm long and 9 - 12 mm broad have been found. At some very sheltered localities, mainly in harbours with eutrophicated waters, forms resembling *Petalonia fascia* var. *debilis* Derb. et Sol. or *Petalonia caespitosa* Le Jol. are found during summer. These forms, which are 4 - 8 cm broad and up to 20 cm long, lack the acuminate base. They are probably only modifications of *Petalonia fascia*.

Petalonia fascia occurs during different seasons in different part of the distribution area:

Area	Season
France	winter
Baltic, Reinke (1889)	winter
Denmark, Rosenvinge & Lued (1947)	all the year except February
Sweden, Kylin (loc.cit.)	April - August
South Norway, Norum (1913)	winter, spring (littoral zone)
Middle Norway, Frintz (1926)	summer, autumn (sublittoral zone)
North-Norway, Jaasund (1965)	same as south Norway
The Faeroes Islands, Børgesen (1902)	June and July
	all the year, mostly in summer

Judging from this data it is possible that *Petalonia fascia* prefers cold water. This agrees very well with Wynne's (loc.cit.) observations from culture studies, that formation of the *Petalonia* stage was, favoured by low temperature and short-day conditions.

In the Öresund the species appears in the middle of August with very rapid growth. In November it is both qualitatively and quantitatively most well developed. From November to March the growth is very small and in April and May most of the specimens are decayed, perhaps due to the prevalent low water during spring. In the middle of June one can find small patches of new specimens but these grow in deeper water. This summer appearance agrees with Norum's (loc.cit.) and Frintz's (loc.cit.) observations. Plurilocular sporangia have been observed throughout the year.

Localities: Abundant in the north part of the area, in the central part on the Danish coast and down to Dragør; Råå, Ålabodarna, Ven, Borstanusen, Landskrona.

Polyhalobe mesoeuxyhaline.

Petalonia zosterifolia (Reinke) Kuntze

Distribution Sweden: Skåne and Halland, Kylin (1947); Kullen, Levring (1935).

Denmark: Kattegatt, The Belt.

The taxonomic status of *Petalonia zosterifolia* has been discussed for a long time. When Wynne (1969) cultured *Petalonia fascia* and its alternating form (*Ralfsia*) he did not find any *zosterifolia*-like stages. The present author is of the opinion that the two species are well separated both morphologically and ecologically. In the Öresund material there are no transitional stages.

Petalonia zosterifolia is abundant in the north part of the area and more sparsely to the line Landskrona - Dragør. South of this line no finds have been made (Fig. 102). The species appears from August to March at exposed to very exposed localities in the sublittoral zone at 0.1 - 0.2 m wide belt about 0.1 -

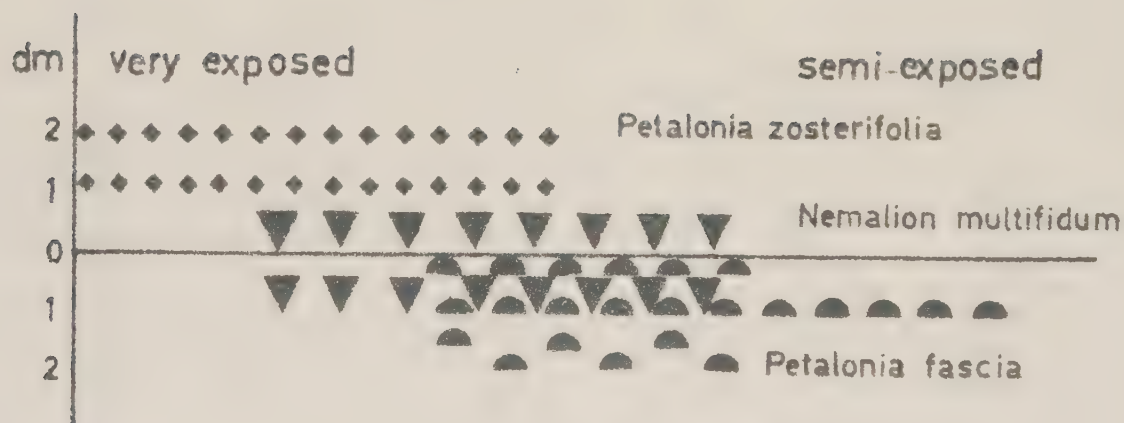


Fig. 103. The vertical distribution of *Nemalion multifidum*, *Petalonia fascia* and *Petalonia zosterifolia* in relation to the degree of exposure.

0.2 m above the 0-line, depending on the degree of wave action. During summer-time a few finds of *Petalonia zosterifolia* have been made but in more sheltered positions and always in the littoral zone 0.2 - 0.5 m below the 0-line. The zonation and preference to exposition compared with *Nemalion multifidum* and *Petalonia fascia* can be seen in Fig. 103.

Petalonia zosterifolia varies in length from 6 - 12 - (20) cm and is usually 0.9 - 1.5 - (2) mm broad.

Like *Petalonia fascia* the species seems to be found at different seasons in different parts of the distribution area:

Area	Season
Helgoland, Kuckuck (1912)	March - April and August - October
Western Baltic, Reinke (1889)	summer, autumn
Denmark, Rosenvinge & Lund (1947)	March - November
Sweden, Kylin (loc.cit.)	April - September
North Norway, Jaasund (1965)	summer

The previous records from the Swedish west-coast may give a false impression due to the time of year when the majority of specimens are growing. Levring (loc. cit.) writes, "Ich habe sie von Mai bis September beobachtet. Die Art kommt in dem ganzen Gebiet vor. Sie scheint aber ziemlich selten zu sein", and Kylin (loc.cit.), "längs der ganzen Westküste verbreitet, spärlich bis selten --- fertil im April bis August".

According to the present author's observations *Petalonia zosterifolia* appears in the middle of August and reaches almost full length after 2 - 3 weeks. During September to November new specimens continue to grow slowly. From this time *Petalonia zosterifolia* forms a distinct and rather narrow belt. In March most specimens seem to die and are rapidly decayed. At some shaded localities a few specimens can survive until May. The species seems to grow in short-day and low temperature conditions, like *Petalonia fascia*. Plurilocular sporangia, 5 - 6 x 40 - 50 μ , have been found throughout the year but mainly from September to March.

Localities: Abundant in the north part of the area; Snökkersten, Båå, Ålabodarna, Helsingør, Ven, Landskrona, Taarbæk, Skogshoved, Tre Kroner, Dragør.

Scytosiphon lomentaria (Lamour.) Link.

Scytosiphon lomentaria (Lamour.) Link

Distribution (Sweden): Bohuslän and Halland, Kylin (1947); Kullen, Levring (1935); Blekinge, Levring (1940); Gotland, Ridelius (1933); Blå Jungfrun, Du Rietz (1941); Nynäshamn, Du Rietz (1930).

Denmark: All districts.

Kawachi (1966) and Lund (1966) found a heteromorphic life-cycle in *Scytosiphon lomentaria*. The species which is common along the Swedish coasts, is very variable in morphology and a number of different forms have consequently been described. According to the author these forms only seem to be modifications due to changes in the environment.

Scytosiphon lomentaria is common along the Swedish and Danish coasts of the Öresund area. During the last 5 - 6 years it has disappeared more or less irregularly in some areas of the central part of Öresund, e.g. in the Lomma and Lundåkra Bays. The species grows in a belt from the 0-line down to 20 cm below. Single specimens are found down to 1 m in depth.

At exposed localities *Scytosiphon lomentaria* is 0.5 - 1 mm broad and (4) - 6 - 10 cm long with few or no constrictions. In low-lying rock-pools up to 3 m above the 0-line similar forms are found but often a little shorter, 3 - 6 cm. At sheltered localities the specimens are 1 - 1.5 mm thick and 13 - 18 cm long. In sheltered positions the thalli are often more elongated and have more frequent constrictions. In water with high contents of nutrients the specimens have been

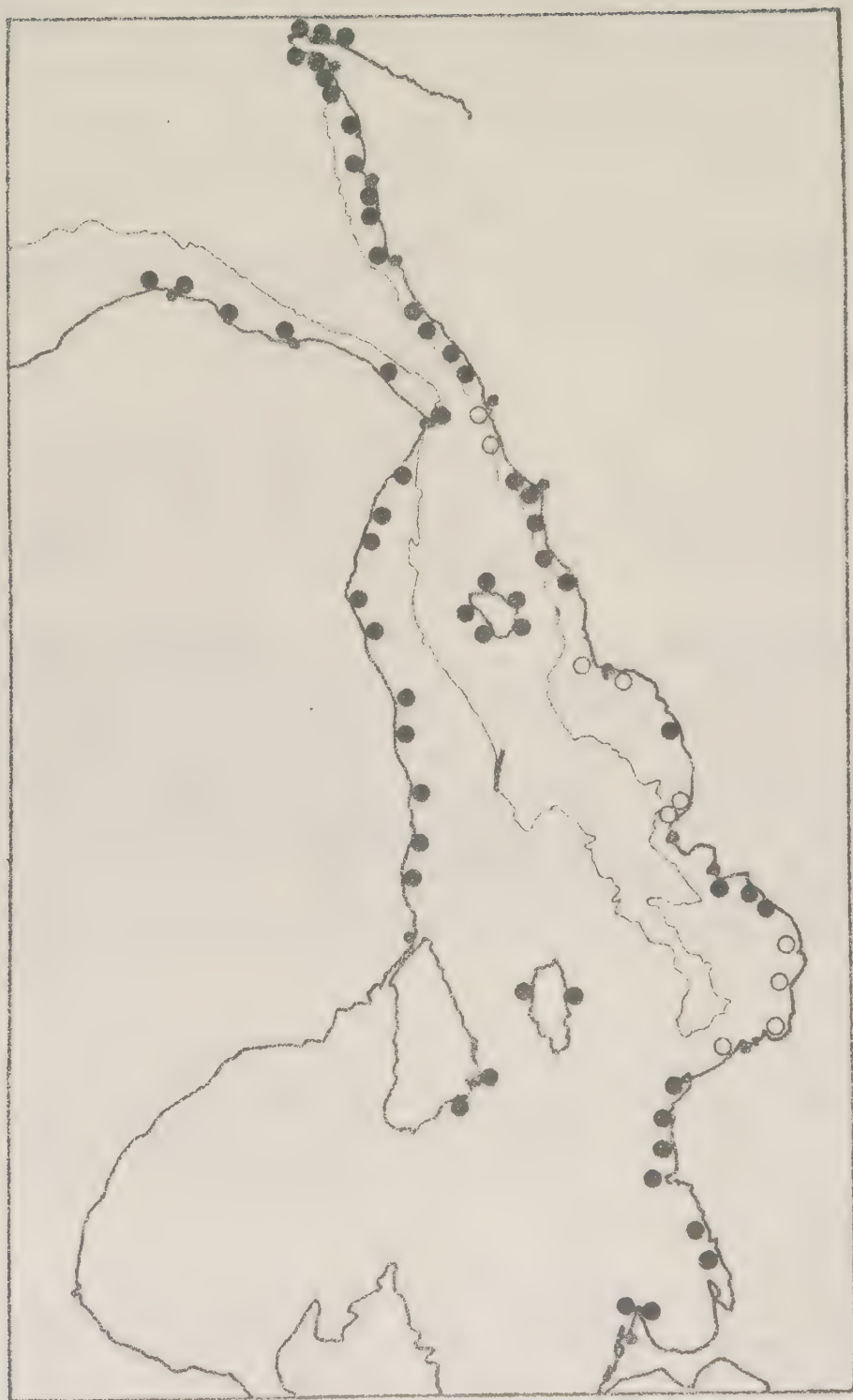


Fig. 1. The distribution of *Scytosiphon lomentaria*.

- recent finds
- finds in 1964 - 1967

served which are more than 3 mm thick and 30 - 50 - (90) cm long. The number of hairs varies in relation to the wave action on the place of growth. At the most exposed localities they cover the thalli almost completely.

The first sign of *Scytosiphon lomentaria* is usually found in January when small specimens, 5 - 15 mm high, appear. These early specimens do not always survive. They are often damaged by frost and/or drying during the low-water period in early spring. But probably the basal discs survive and give rise to new thalli when the conditions are more favourable. According to Wynne's (1969) culture studies, growth seems to be favoured by short-day conditions and cold water. The main development of the species occurs from the end of March to the end of May. The thalli reach maximum length in only a few weeks and from the middle of June the thalli start to decay and are often covered with various epiphytes, such as *Ectocarpus* sp. and *Myriotrichia claviformis*. Single specimens can survive to August. In September and October a new generation of *Scytosiphon lomentaria* is sometimes seen but always in very limited numbers.

Plurilocular sporangia which in most cases are larger than the paraphyses, measure 10 - 20 x 50 - 70 μ . The number of tiers varies from 6 - 15. This variation seems to be correlated to the wave action on the place of growth. Plurilocular sporangia have been found from April to July and September to October.

Localities: Common in the whole area. (Fig. 104)

Polyhalobes pleioeurhale.

DESMARESTIALES

Desmarestiaceae

Desmarestia aculeata (L.) Lamour.

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Kullen, Levring (1935).

Denmark: All districts except Sønderhavet.

Desmarestia aculeata is abundant in the north and central part of the Öresund. South of the line Limhamn - Dragör the author has not found any *Desmarestia aculeata*. Hornemann (1837) reports a find at Bornholm in the Baltic. Since then the species has not been found in this area. *Desmarestia aculeata* grows from 10 - 25 m in depth on different types of bottoms, stone, shell and sandy, muddy bottoms with small pebbles or shells. On muddy bottoms in the central part of the Öresund *Desmarestia aculeata* and *Laminaria* sp. form the dominant part of the algal vegetation at 10 - 15 m in depth. The old basal parts of *Desmarestia aculeata* often have a rich epiphyte flora, such as *Acrochaetium daviesii*, *Audouinella efflorescens*, *Delesseria sanguinea*, *Porphyropsis coccinea* and *Rhodochorton* sp.

The thalli are as a rule 1 - 1.5 mm thick and 40 - 60 - (70) cm long. Both the thalli and the spinelike shoots are much slender in the Öresund, although they often have the same length as specimens collected in the north of Kattegatt and Skagerrak. The growth of the perennial part starts as a rule in the middle of February and ends in the last part of May. The hairs which more or less cover the new shoots during growth are shed during May and in June most of the hairs are lost.

Localities: Abundant in the north and central part; off Dragör, off Limhamn.

Polyhalobes pleioeurhale.

Desmarestia viridis (O.F. Møll.) Lamour.

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Kullen, Levring (1935); Öland, Waern (1965 b).

Denmark: All districts except Smålandshavet:

Concerning the distribution of this species Kylin (loc.cit.) states, "böhusslänschen Küste gemein, an der halländischen spärlich" and from Kullen, Levring (loc.cit.), "nur einige Exemplare".

During the period 1962 - 1967 the author found *Desmarestia viridis* occasionally. From 1968 - 1972 the number of specimens has increased tremendously. During the 1970, 1971 and 1972 30 - 40 % of the algal biomass in late May and June at depths from 10 - 20 m, especially in the north part, has consisted of *Desmarestia viridis*. This huge amount of often free-floating *Desmarestia viridis* has damaged the natural algal communities which are killed, partly by sulphuric acid from the *Desmarestia* and partly by oxygen deficiency during night and when the *Desmarestia* masses decompose.

In the north part of the area *Desmarestia viridis* is now commonly found from 3 - 20 m in depth and in the central part abundantly from 10 - 20 m in depth. South of Klagshamn very few specimens have been found, though according to Rosenvinge & Lund (1943) the species has been found near Bornholm in the Baltic and Waern (loc.cit.) at Öland. The species grows on shells, mainly *Mytilus edulis*, sometimes also on larger algae. Pure *Desmarestia viridis* communities have been observed on "Mytilus banks".

The thalli are about 1 mm near the base and most branches are very thin and slender, the total length varying between 15 - 50 cm. Growth starts in February - March and is vigorous in May and June. During this period the species is very dark brown. In June most specimens are detached and are then light brown. They decay rapidly. In July to September only few specimens are met with. Unilocular sporangia are found from June to September.

Localities: Common in the north part and abundant in the central part; Limhamn, Klagshamn, Bredgrund, Skanör.

Polyhalobe pleiceuryhaline.

LAMINARIALES

Chordaceae

Chorda filum (L.) Staackh.

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Kullen, Levring (1935); Blekinge, Levring (1940); Öregrund, Waern (1952).

Denmark: All districts.

Chorda filum is common in the whole area from 0.5 m below the 0-line down to 10 - 15 m in depth, growing on stones and larger mollusc shells. At the most exposed localities *Chorda filum* is replaced by *Halosiphon tomentosus*.

Specimens growing in sheltered positions reach a length of 2 - 3 m and 3 mm in diameter, while specimens growing at more exposed localities hardly reach more than 1 m in length and a diameter of 2 mm. The main growth takes place in the end of April and in May, when they reach a length of 50 - 75 cm. During this time they are quite covered with colourless, assimilating hairs. Growth continues during summer. *Chorda filum* is detached and disappears in October and November. Unilocular sporangia, as a rule $8 - 12 \times 30 - 40 \mu$, are found from May to October.

Localities: Common in the whole area.

Polyhalobe pleioeuryhaline.

Halosiphon tomentosus (Lyngb.) Jaasund

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Blekinge, Levring (1940).

Denmark: All districts except Bornholm.

Halosiphon tomentosus is abundant in the whole area but with decreasing frequency towards the south part. The species grows at exposed to semi-exposed localities from 0.5 - 1.5 - (3) m below the 0-line on stones.

The specimens are 0.75 - 1 m long, 2 mm thick and quite covered with dark brown hairs. The thalli often grow in small groups of 10 - 20 specimens together. Like *Chorda filum*, *Halosiphon tomentosus* starts its development in the later part of February. At the beginning of May the juvenile plants are about 10 cm high and in the end of May and the beginning of June the species reached its maximum development. At the end of June it begins to die; no finds have been made in July. Unilocular sporangia, 12 - 16 x 80 - 100 μ , are found from April - May - (June).

Localities: Hovs Hallar, Hallands Väderö, Kullen, Lerhamn, Höganäs, Gilleleje, Hornbæk, Helsingör, Helsingborg, Ven, Barsebäck, Tuborg, Saltholm, Limhamn, Skanör, Klagshamn, the canal of Falsterbo.

Polyhalobe pleioeuryhaline.

Laminariaceae

Laminaria digitata (Huds.) Lamour.

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Kullen, Levring (1935).

Denmark: All districts except Smålandshavet and Bornholm.

The species is variable in size and morphology, e.g. f. "genuina" Le Jol., f. *stenophylla* Harv. and f. "intermedia" Fensholt which is conspecific with *Laminaria cucullata* (Le Jol.) Fensholt. These variant forms are probably merely modifications.

According to Kylin (loc.cit.) *Laminaria digitata* is "gemein (Bohuslän) bis ziemlich spärlich (Halland) --- an offenen Lokalitäten in einer Tiefe von 1 - 3 m vor, tritt an der halländischen Küste erst in einer Tiefe von 2 - 5 m auf".

Laminaria digitata is common in the north and central part of the area; in the south part single specimens are frequently found down to Bredgrund (NW of Skanör). On the north side of Kullen one can find a *Laminaria digitata* belt from 0.6 m below the 0-line to 3 m in depth and scattered specimens down to 25 m. In the Öresund proper *Laminaria digitata* is common below 10 m in depth on stones.

The length of the stipes varies from (6) - 10 - 75 cm, according to Rosenvinge & Lund (1947) 2 - 35 cm. Specimens with 2 - 3 phylloids on the same stipes are found in low numbers. Such a form has also been found by Suneson (1971) from the Swedish west-coast. The phylloids vary from 30 - 160 cm in length. They are usually around 40 cm broad but phylloids, 50 - 70 cm broad, are not uncommon. The growth of *Laminaria digitata* as well as *Laminaria saccharina* begins very slow in October and the main growth takes place in January to April. Unilocular sporangia are found from June to May.

Localities: Common in the north and central part: W. Limhamn, W. Klagshamn, Bredgrund. (Lir. 1935)

Polychaete mesoeuryhaline

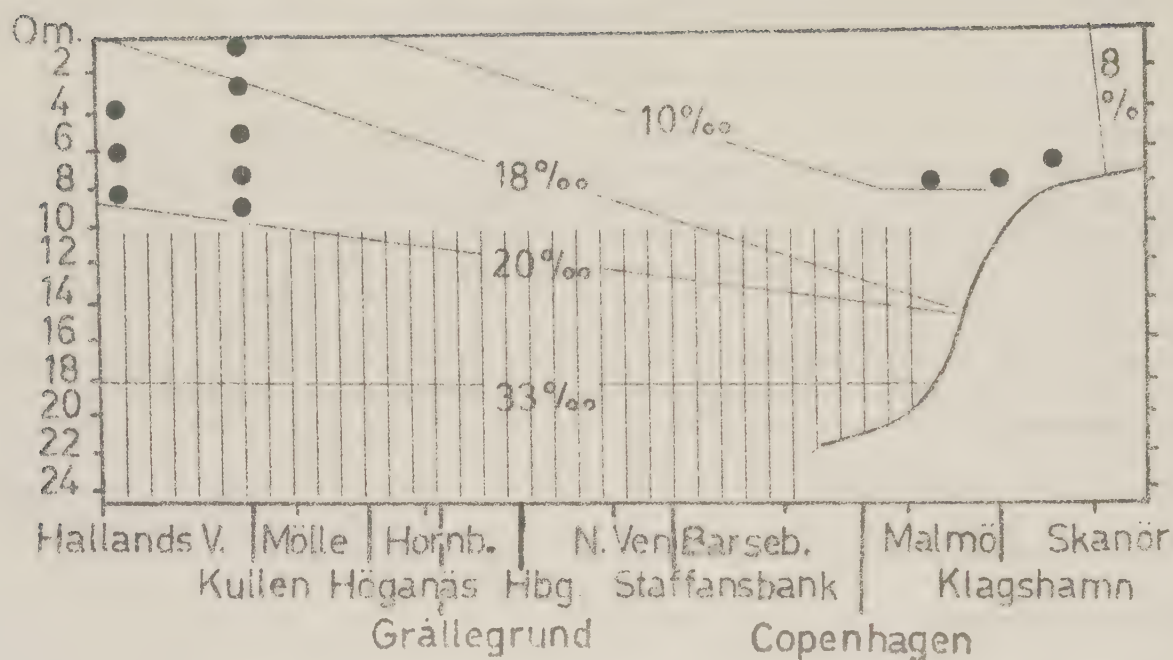


Fig. 105. The distribution of *Laminaria digitata* in relation to depth and salinity.

||||| common

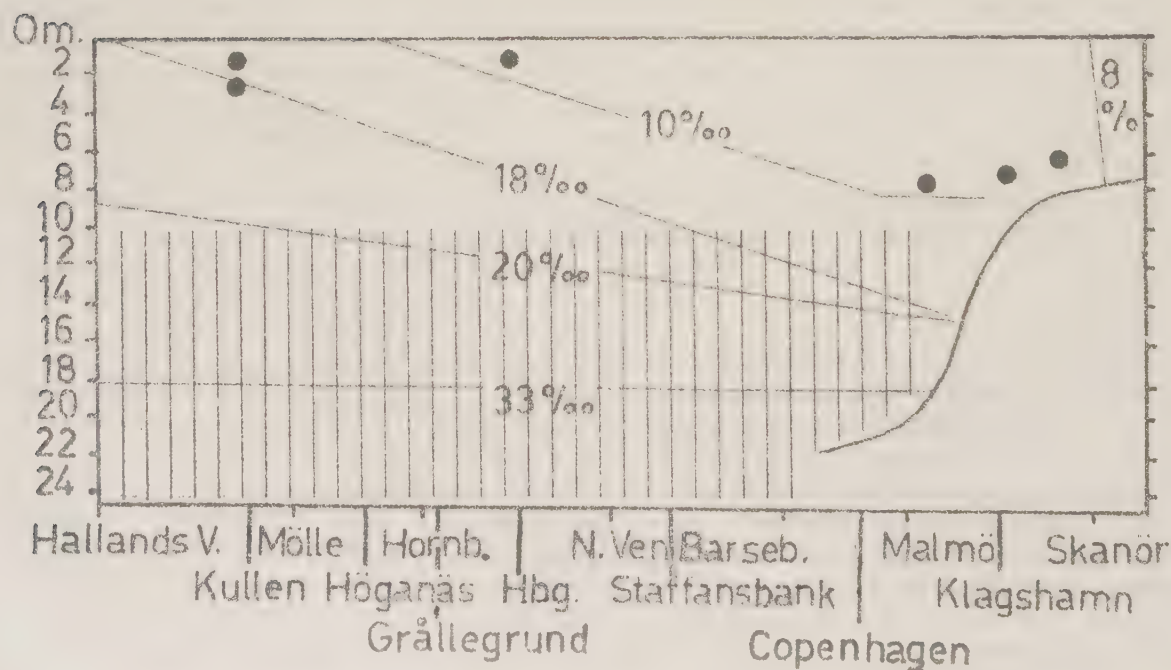


Fig. 106. The distribution of *Laminaria saccharina* in relation to depth and salinity.

||||| common

Laminaria saccharina (L.) Lamour.

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Kullen, Levring (1935).

Denmark: All districts except Smålandshavet.

Laminaria saccharina occurs in the Öresund in three morphological forms, f. *bullata* C. Ag., f. *membranacea* J. Ag. and f. *sublaevis* Kjellm. There are, however, transitional stages between these forms and they most probably are modifications. In the south part of the area f. *membranacea* seems to dominate.

Laminaria saccharina is common in the north and central part and frequent in the south part of the Öresund. It is mainly distributed from 10 - 25 m in depth but on the north side of Kullen some years one can find patches of *Laminaria saccharina* from 1 m in depth. Such finds have also been made in the north harbour of Helsingör. The colonisation of *Laminaria saccharina* at this depth, however, is unsuccessful. The specimens at these localities can survive 1 - 2 years and then disappear. The species grows on stones, pebbles and *Cyprina* and *Mytilus* shells.

The length of the stipes is variable, the normal range is between 2 - 50 cm. In the Lomma Bay on muddy bottoms where *Laminaria saccharina* grows on shells and pebbles, however, the normal length of the stipes is 10 - 20 cm and at most 30 cm long. In these areas also 1 - 2 periphytes have been observed on the same stipes. The stipes with prominent hapteria have frequently been observed. In the north and central part of the Öresund the normal stipe length is about 1.5 m, the average spore length being 1.5 m. The normal breadth of the phylloid is 20 - 30 cm but specimens up to 40 cm broad have been found. South of the line Lomma - Kullen the specimens are smaller and reduced to stipes with phylloids 10 cm long.

Growth begins in late September and is slow until December. From December to April the growth is rapid. The first phylloids are shed in April but in a few cases old phylloids have been met with in May and June. Unilocular sporangia are observed throughout the year but more frequently from July to December. Zoospores, 5 - 10 μ in diam., are found in March to April.

Localities: Common in the north and central part; W. Limhamn, W. Klagshamn, Bredgrund. (fig. 106)

Laminaria saccharina

SPHACELARIALES

Sphacelaria bipinnata

Sphacelaria bipinnata (Kütz.) Lamour.

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Kullen, Levring (1935).

Denmark: All districts, except The Belts.

This species is frequently found in the north part of the area from 6 - 15 m in depth as an obligate epiphyte on *Halidrys siliquosa*. South of Kullen the author only found *Halidrys siliquosa* with *Sphacelaria bipinnata* once, from 20 m in depth. Loose-lying specimens on drifting *Halidrys siliquosa* can be found as far south as Falmö but all these specimens emanate from the Lomma and very soon decay. The species, which is 15 - 20 mm long, is found from May to November. Unilocular sporangia, 60 - 80 μ in diameter, are frequently found from June to November. Plurilocular sporangia have been found on one occasion in the beginning of July; they were 36 - 40 x 60 - 80 μ .

Localities: Off Hovs Hallar, off Torekov, Hallands Väderö, Kullen, Vattenmöllan.

Sphacelaria britannica Sauv.

Distribution Sweden: Bohuslän, Kristineberg, Kylin (1947); Hallands Väderö, Suneson (1939 b); Kullen, Höllviken, Waern (1945); Öregrund, Waern (1952).

Denmark: N. Kattegatt; Copenhagen, Lund (1950).

The author has only found this species once, at Kullen in June. It was growing at a very exposed locality about 10 cm above the 0-line in the *Pilayella rupincola* belt. *Sphacelaria britannica* is apparently scarce but also very easily overlooked when it grows together with *Pilayella rupincola*. It probably has difficulties in competing with this species. The specimens were about 10 mm long and the filaments 15 - 25 - (30) μ broad. Unilocular sporangia, (30) - 35 - (40) μ in diameter, were numerous but partly emptied. Kylin (loc.cit.) reports unilocular sporangia during winter.

Locality: Kullen.

Polyhalobe pleiceuryhaline.

Sphacelaria caespitula Lyngh.

Distribution Sweden: Bohuslän, Koster, Väderöarna, Kristineberg and Halland, Fjordskär, Varberg, Morup, Kylin (1947).

Denmark: N. Kattegatt.

On three occasions specimens of *Sphacelaria caespitula* have been obtained in the north part of the area from 20 - 25 m in depth growing on shells. From a basal disc several erect filaments grew up which were 2 - 3 mm long, rather thin, 19 - 25 μ . There was little difference in thickness between the basal and upper part of the filaments. The filaments were very sparsely branched. One find was made in February and the material was sterile. The other finds were made in May and June and in these cases some emptied plurilocular sporangia were borne on small branchlets. The sporangia were rather large, 60 - 60 μ in diameter.

Localities: Vattenmöllan, Hornbæk Bay, W. Helsingborg. (Fig. 107)

Polyhalobe oligoeuryhaline.

Sphacelaria cirrosa (Roth) C. Ag.

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Skälderviken, Lönnberg (1903); Kullen, Levring (1935); Blekinge, Levring (1940).

Denmark: Kattegatt, Samsö, Little Belt, Öresund, W. Baltic, Bornholm.

Levring (1935) considered the species to be "gemein in der Sublitoralregion epiphytisch auf mehreren, gröberen Algen". *Sphacelaria cirrosa* is today rather sparsely distributed in the north and central part of the Öresund from 5 - 20 m in depth, growing on i.a. *Laminaria* stipes and *Rhodomela confervoides*. The filaments are usually 5 - 10 mm long and 40 - 50 μ broad. Unilocular sporangia have been found from May to September.

Localities: Hovs Hallar, off Hallands Väderö, Kullen, Vattenmöllan, Gilleleje lack, Grälleggrund, Staffansbank, N. Saltholm fläck.

Polyhalobe pleioeuryhaline.

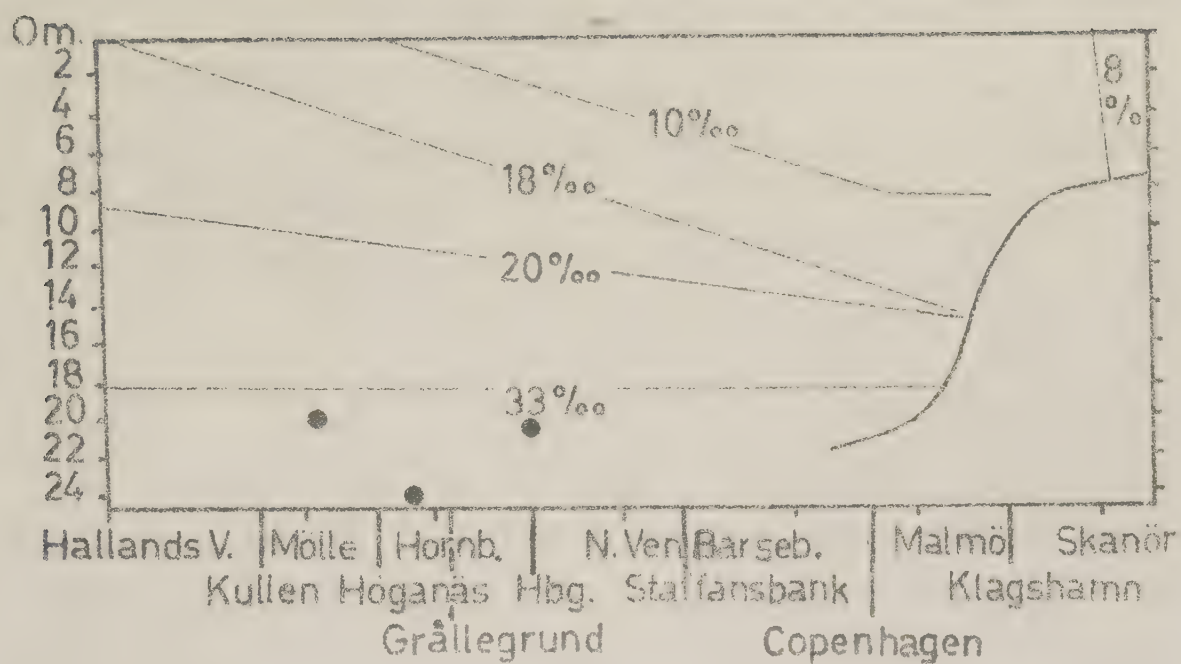


Fig. 107. The distribution of *Sphacelaria caespitula* in relation to depth and salinity.

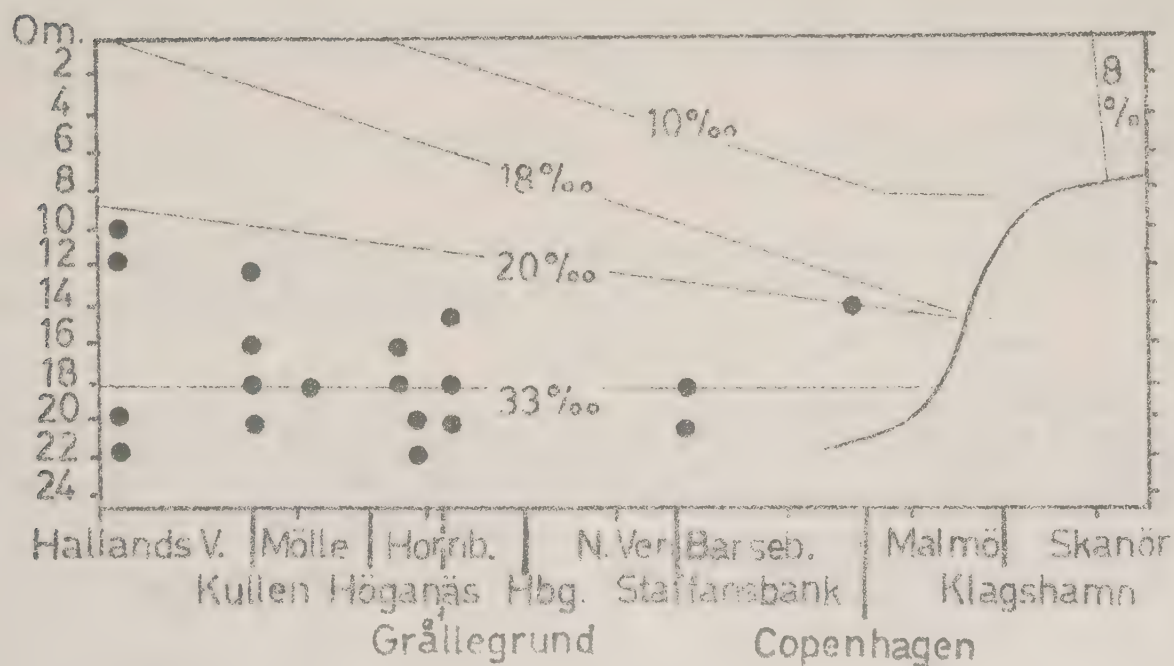


Fig. 108. The distribution of *Sphacelaria plumosa* in relation to depth and salinity.

Sphacelaria plumigera Holm.

Distribution Sweden: Bohuslän, Marstrand, Areschoug in Waern (1945); Möllviken, the Baltic, Ångermanland, Waern (loc.cit.).

Denmark: N. Kattegatt, Samsö, The Belts, Öresund, the Baltic proper.

This species, which is rare in the north of Kattegatt and Skagerack, is also found in a detached form as a relict in the Baltic. The author has only found it once in the Öresund. A loose specimen of the f. pinnata Reinke, which was entangled in a Cladophora glomerata, was washed ashore near Skanör in the southernmost part of the area.

Locality: Skanör.

Polyhalobe pleioeuryhaline.

Sphacelaria plumosa Lyngb.

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Kullen, Levring (1935).

Denmark: Kattegatt, Samsö, The Belts, Öresund, W. Baltic, Baltic Möen.

This species was frequently found in the north part of the area and rarely in the central part up to 1971. Since then no finds have been made. It grows from (10) - 15 - 25 m in depth on stones and shells and in a few cases on Odonthalia dentata and Phyllophora brodiaei. The thalli are 4 - 5 cm long in the north part, at Grålleggrund and Staffansbank 1 - 3 cm long. Lund (1950) gives the length from Kattegatt as 4 - 10 - (12.5) cm. The species has been found throughout the year. Most of the specimens have been sterile, but some specimens collected in December, February and March bore plenty of unilocular sporangia on fructiferous branches.

Localities: Off Hallands Väderö, Kullen, Vattenmöllan, Gilleleje flack, Hornbaek Bay, Grålleggrund, Staffansbank, N. Saltholm. (Fig. 108)

Polyhalobe meioeuryhaline.

Sphacelaria radicans (Dillw.) C. Ag.

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Kullen, Levring (1935); Simrishamn, Krok (1869); Öregrund, Waern (1952).

Denmark: Kattegatt, Samsö, Öresund.

This species is frequently found in the north part of the area, growing at semi-exposed localities from the 0-line to 1.5 - (3) m in depth on stones. Though according to Waern (loc.cit.) the species is rather common in the Öregrund area, it has never been found in the central and south part of the Öresund area. The filaments are 8 - 12 mm long and 35 - 55 μ broad. The dark brown tufts are mainly seen in the winter from November to April. Very few specimens have been found during the rest of the year. Unilocular sporangia, 40 - 60 μ in diameter, have been observed from December to April.

Localities: Hovs Hallar, Hallands Väderö, Kullen, Lerhamn.

Polyhalobe pleioeuryhaline.

FUCALES

Fucaceae

Ascophyllum nodosum (L.) Le Jol.

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Kullen, Levring (1935).

Denmark: Kattegatt.

This species is conspicuous along the Swedish west-coast and in the north part of the Öresund, though Kylin (loc.cit.) states, "südlichen Teilen der halländischen Küste nur in zerstreuten Individuen vorhanden". *Ascophyllum nodosum* has its south border of distribution at Mölle. The border is very distinct. The species forms a belt along the coast of Kullen and at Mölle it stops abruptly. This is, however, not due to lack of suitable substratum. The specimens at the south limit show no abnormality either in morphology or fructification.

The *Ascophyllum nodosum* belt is situated in sheltered positions about 30 - 50 cm below the 0-line between *Fucus vesiculosus* and *Fucus serratus*. *Ascophyllum nodosum* can also grow singly in the sublittoral zone down to 4 m in depth and in rock-pools up to 5 m above the 0-line. At a few localities some single specimens have been found just above the 0-line. These forms are reduced, have no vesicles and are sterile. They have about the same appearance as *Ascophyllum nodosum* f. *scorpioides* (Hornem.) Hauck. This form is most probably only a modification. Apparently there is a difference in the habitats as Jaasund (1965) states, "with increasing wave action, it is obviously more tolerant than *Fucus vesiculosus*, but disappears on moderately exposed places". In the Öresund the reverse is true. In very exposed places, however, where *Fucus vesiculosus* & *compressus* f. *racemosa* is found, single specimens of small *Ascophyllum nodosum* can reappear, very stiff and "bushy".

The normal length of the species in the area varies between 40 - 80 cm but specimens up to 100 cm have been found. The breadth varies from 3 - 8 mm. Receptacles begin to grow in November or December and are mature from April to May when they are shed.

Localities: Hovs Hallar, Torekov, Hallands Väderö, Kullen, Mölle; no finds on the Danish coast.

Polyhalobe mesoeuryhaline..

Fucus distichus ssp. *edentatus* (Pyl.) Powell

(*Fucus inflatus* L.)

Distribution Sweden: Bohuslän, Strömstad, von Wachenfeldt (unpubl.); Fjällbacka, Hylmö (1933); Göteborg, Levring (1946); Göteborg archipelago, Lindgren (1965); Halland, Varberg, Hylmö (loc.cit.); Malmö, Lund (1956).

Denmark: N. and S. Kattegatt; Copenhagen, Lund (1949).

The taxonomic status of this fucoid, originally described by Linné as *Fucus inflatus*, is revised by Powell (1957 a, b) who transferred it to *Fucus distichus*.

The species has spread from its original distribution area during this century. Börgesen (1902) reported one locality from the Shetland Islands. In Sweden its immigration was reported first by Hylmö (loc.cit.) based on a collection by Ryström in Fjällbacka 1924 and some own finds in Varberg. Levring (loc.cit.) found the species in the vicinity of Göteborg 1946. The distribution in the Göteborg area has been described by Lindgren (loc.cit.). In the Öresund Lund (1949, 1956) found the species in Copenhagen 1948 and in Malmö 1955. Today it is found at every suitable



Fig. 109. The distribution of *Fucus distichus* subsp. *edentatus*.

locality in the Öresund area. Hylmö (loc.cit.), Lund (1966) and Powell (1957 b) have discussed how the species has migrated from its normal distribution area and suspect ships as a probable means of transportation. For the distribution in the Öresund free-floating zygotes may be the probable explanation.

In contrast to other fucoids *Fucus distichus* ssp. *edentatus* has a discontinuous distribution (Fig. 109). The species with few exceptions only grows in sheltered positions in harbours. This agrees fully with Powell's (loc.cit.) experience from the Shetland Islands and Fair Isle. The species forms a belt from 0.2 - 1 - (1.5) m below the 0-line. It is in contrast to other fucoids almost devoid of epiphytes. *Elachista fucicola*, however, is sometimes found in low numbers on the basal parts of old specimens. The species can compete successfully for space with other fucoids. It is sometimes found growing together with *Fucus serratus*. At most localities where the immigration of the species has been followed for many years it is obvious that *Fucus distichus* ssp. *edentatus* has almost completely overtaken the *Fucus vesiculosus* niche.

At a few localities the species does not grow in harbours. These localities are:

1. A semi-exposed rock-pool at Kullen where the nutrient concentration is high due to decaying algal material, irregularly washed in by wave action. Here, *Fucus vesiculosus* has been totally replaced by *Fucus distichus* ssp. *edentatus* within the space of two years.
2. A rather exposed position south of Mölle just outside the mouth of a little "fjäll". Here, *Fucus distichus* ssp. *edentatus*, *Fucus serratus* and *Fucus vesiculosus* are growing together in balance.
3. On the outside of the pier at Lerhamn. A few specimens are growing mixed with other *Fucus* species. *Fucus distichus* ssp. *edentatus* has not succeeded in expanding at this locality in spite of having fully superseded *Fucus vesiculosus* in the harbour itself.
4. Outside the harbours of Tuborg and Limhamn. The species is here belt-forming.

The choice of growth place inside harbours could depend either on a need for shelter or on that the species is favoured by high amounts of nutrient salts. Jaasund (1965), however, has recorded the species from sheltered to moderately exposed localities. The cases mentioned above indicate that the species can grow at semi-exposed localities but with reduced ability to compete with other fucoids. A closer examination reveals that *Fucus distichus* ssp. *edentatus* always grows where there is a high level of nutrient salts. This is in agreement with Powell's (1957 b) observations from the Shetland Islands.

Fucus distichus ssp. *edentatus* in the Öresund is usually 20 - 25 cm long and the thalli are about 10 mm broad near the base, 6 - 7 mm near the apex. In comparison with Powell's (1957 a) description, the Öresund specimens are reduced forms. Even within the Öresund material there is a marked tendency to more reduced forms towards the south. The number of caecostomata seems to be reduced in the Öresund area. Powell (1957 a) counted up to 500/cm². Jaasund (loc.cit.) found "numerous" caecostomata in his material from north Norway. In the Öresund the number of caecostomata could be estimated to 10 - 20/cm² at most and they are very difficult to find without sectioning the thalli.

At Kullen the total length of the receptacles are about 5 cm, while in Klagshamn, the southernmost locality for the species, the receptacles seldom reach more than 1.5 - 3 cm in length. The fruiting organs begin to develop in January and mature receptacles are found from the middle of February to May, when they are shed. Lindgren (personal communication) has observed fruiting specimens near Göteborg from April to June, Jaasund (loc.cit.) June to August and Powell (1957 b) June and July. In culture, mature eggs have been observed to leave the conceptacles but remain attached to the receptacles by means of a "slime cord", about 2 - 3 mm long. This seems to be the case even in nature, probably a means of getting as many eggs as possible fertilized. Similar phenomena have not been observed on other fucoids.

Localities: Torekov 1962, Arild 1966, Kullen 1966, Mölle 1967, Vattenmöllan 1964, Lerhamn 1965, Höganäs 1966, Viken 1967, Gilleleje 1964, Hornbæk 1965, Helsingör 1964, Helsingborg 1966, Ven 1967, Landskrona 1967,

Malmö 1955 (Lund, 1956), Limhamn 1962, Klagshamn 1964, Tuborg 1962, Copenhagen, Tre Kronor 1967. (The year is the first observation by the author in the respective localities.) (Fig. 109)

Polyhalobe mesoeuryhaline.

Fucus serratus L.

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Kullen, Levring (1935); Blekinge, Levring (1940); Småland and Gotland, Krok (1869).

Denmark: All districts.

Fucus serratus varies in morphology. The "variation breadth", however, is by no means on the same scale as for *Fucus vesiculosus*. In the Öresund material the following of Kjellman's forms have been recorded: *f. abbreviata*, *f. angusta*, *f. arctica*, *f. elongata*, *f. grandifrons*, *f. laciniata* and *f. typica*. Except for *f. grandifrons*, all the named forms have been found in the whole area. There is maybe a correlation between morphology and the following parameters: depth, substratum, grade of exposition to wave action and currents.

Thus *f. angusta* is found below 5 m in depth, mainly on shell-covered bottoms. *f. arctica* is recorded below 5 m in depth on cliffs. *f. elongata* is only met with at very exposed localities 0.5 - 0.75 m below the 0-line. *f. typica* is distributed at rather sheltered localities from 0.3 - 3 - (4) m below the 0-line on cliffs and pebbles or sandy bottoms. *f. grandifrons* is only found in the south of Öresund in the area Limhamn - Bredgrund - Drogden - Saltholm. This form of *Fucus serratus* can reach a length of 75 - 80 - (100) cm and the breadth of the thalli varies between 5 - 6 cm with rough, double-toothed projections. This form is probably induced by strong currents. The author has seen similar forms at a locality in Bohuslän in a very narrow sound (about 30 m wide) with very strong currents. Judging from the facts above and that transitional stages exist between all forms in the Öresund material, it is highly probable that the different forms are only modifications.

Fucus serratus s.l. is very conspicuous in the whole area. It forms a belt at sheltered to exposed localities from about 0.5 - 6 m below the 0-line. The upper limit forms the border between the littoral and sublittoral zone. Single specimens are found down to 20 m in depth. At very exposed localities on cliffs with an angle of about 90 - 140 ° to the water level the species is not found until from 2 - 4 m in depth. In rock-pools 1 - 6 m above the 0-line at Kullen and Hallands Väderö single, reduced, seldom fertile specimens are found. Fertile *Fucus serratus* is found from August to April. The main part of the gametes, however, are released during September - November.

Localities: Common in the whole area.

Polyhalobe pleioeuryhaline.

Fucus spiralis L.

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Kullen, Levring (1935).

Denmark: N. and S. Kattegatt, Samsö.

This species has a very restricted distribution in the investigation area. It is found at Hallands Väderö and Hovs Hallar as small fragments of the normal *Fucus spiralis* belt as it is seen in Bohuslän at semi-exposed to sheltered localities just above the 0-line. At Kullen it appears in very restricted numbers, as single specimens, which are easily damaged by ice in wintertime. The species has very low ability to compete for space in waters with low salinity.

The specimens at Hallands Väderö and Hovs Hallar belong to the main form. The specimens observed at Kullen belong to the nana-form and are only 8 - 10 -

Polyhalobae meioeuryhaline.

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Kullen, Levring (1935); Blekinge, Levring (1940); Öregrund, Waern (1952); Ulvöarna, Arvidsson (1938).

Fucus vesiculosus is one of the most common and widespread algae along the Swedish coasts. The species is very variable in morphology. Kjellman (1890) has described 24 different forms. To these Kylin (1967) added a *f. acuta*. Kjellman (loc. cit.) divided these forms into four form series: *acutatus*, *3* *hauricus*, *γ* *subfusiformis* and *δ* *compressus*. *Fucus vesiculosus δ* *compressus f. racemosa* is very variable and probably conspecific with *Fucus vesiculosus* L. *f. linearis* (Muds.). The only difference between material collected at Kullen and material from Great Britain det. Powell is that the Swedish material is somewhat thinner in the basal parts. This is probably due to differences in exposition to wave action. Variations in the *Fucus vesiculosus* morphology have been noted in other parts of the distribution area, i.e. in France and Spain by Seoane-Camba (1966).

Fucus vesiculosus α . *rotundatus* f. *flabellata*
terminalis
rugida
typica
var. ruga
3 *barticus* f. *aggregifolia*
typica
 γ *subfusiformis* f. *lanceolata*
 δ *compressus* f. *acuta* (Kylin)
compressa
typica

5 - 10 - (13) cm and always without vesicles. They seldom reach the fertile stage. These forms have a wide ecological amplitude. They can survive being frozen in ice for up to two months and can withstand high temperatures in summer.

The background to the astonishing morphological variations is not clear. It may either be genetically bound through the rise of different genotypes or merely modifications. In the author's opinion probably the balticus series is genetically separated from the other forms, while all the others are modifications. This is supported by the distinct border in distribution for the balticus series which can only live in a salinity of 3 - 8 o/oo. In the other series there are as a rule transitional stages between all the different forms. One example is shown in Fig. 112 from a little skerry at Kullen where the exposition varies from very exposed to sheltered. Here one can find a gradual change in morphology, both horizontally and vertically. Thus, the different forms should not possess any taxonomic rank. For practical ecological purposes, however, the names could be kept.

In the Öresund area *Fucus vesiculosus* s.l. is common and forms a belt from the 0-line to 0.5 m in depth. Solitary specimens are found down to 12 m. In the southernmost part of the area the *Fucus vesiculosus* belt is found from 0.5 - 1.5 m below the 0-line. The length of the specimens generally varies from 5 - 40 cm and the breadth from 5 - 70 mm. The average age counted as generations of vesicles is 3 - 4 years. In Lomma Bay there are specimens which are 6 - 8 years old, varying in length from 0.7 - 1.2 m. Fertile specimens are found from February to October but most conspicuously from May to August. The compressus specimens seem to be fertile one or two months before the other forms.

Localities: Common in the whole area.

Polyhalobes pleiceuryhaline.

The author has frequently found fucoids which could not possibly be referred to any known species. These are most probably hybrid forms between *Fucus vesiculosus* and *Fucus spiralis* or *Fucus compressus* and *Fucus distichus* ssp. etc. Some of them are depicted in Figs. 113 and 114.

Burrows (1954) has shown that *Fucus vesiculosus* and *Fucus spiralis* can be successfully crossed with each other. Parriaud (1954) crossed *Fucus vesiculosus* and *Fucus chalonii* and the offspring reached normal size and fertility in the field.

Cystoseiraceae

Halidrys siliquosa (L.) Lyngh.

Distribution Sweden: Bohuslän and Halland, Kylin (1947); Kullen, Levring (1935).

Denmark: Kattegatt, Samsø, The Belts, W. Baltic.

Kylin (loc.cit.) states "in einer Tiefe von 1 - 5 m --- Bestände bildend". *Halidrys siliquosa* is sparse in the north part of the Öresund. From 6 - 15 m in depth single specimens of normal size, about 40 - 90 cm long, and normal light brown colour are found. From 15 - 25 m in depth, stunted sterile forms, 10 - 20 cm long, and almost completely black have been obtained. The southernmost locality where attached specimens can be seen is Grållegrund at 10 - 15 m in depth. Drifting specimens of considerable length, often 1 - 1.2 m, are frequently found in the central and south part of the Öresund. These specimens, however, have not originally grown in the area, and they don't seem to survive for any length of time. They rapidly fragment and decay after a short time. Fruiting specimens are found from April to August.

Localities: Hallands Väderö, Kullen, Vattenmöllan, Gilleleje, Grållegrund. (Fig. 115)
Polyhalobes meioeuryhaline.



Fig. 110. The distribution of *Fucus vesiculosus* and related forms.

- //// *F. ribellata* and *F. capricornis*
- *F. turgida*
- *F. vadorum*



Fig. 111. The distribution of *Fucus vesiculosus* form series.

////// *balticus*

● *F. subfusiformis*

▲ *F. compressus* f. *racemosa* and *typica*

■ *F. compressus* f. *acuta*

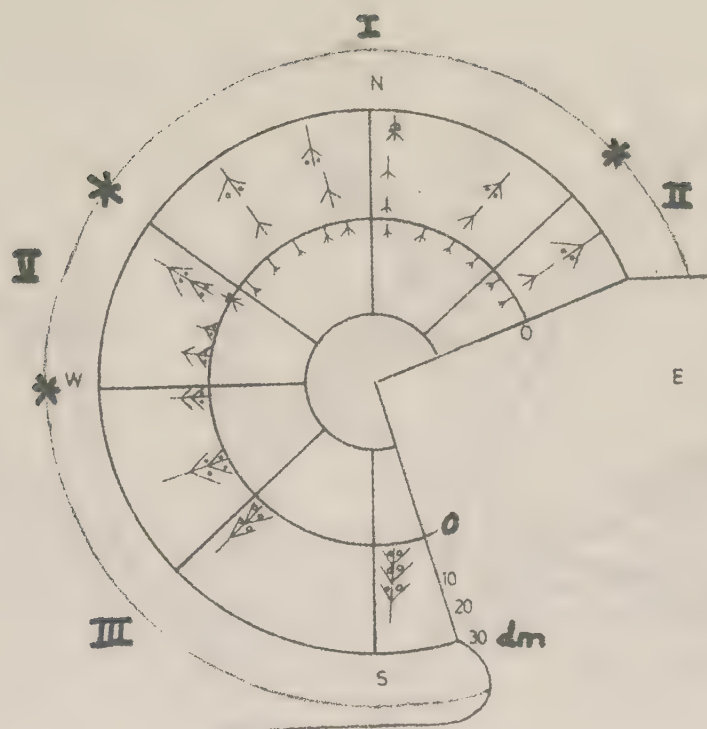


Fig. 112. Morphological variations of *Fucus vesiculosus* in relation to depth and degree of exposure at a small skerry off Kullen. I = very exposed II = semi-exposed III = sheltered The signs are proportional to the size of the thalli and vesicles.



Fig. 113. A *Fucus hybride* (x 0.5) from Mölle 1970.

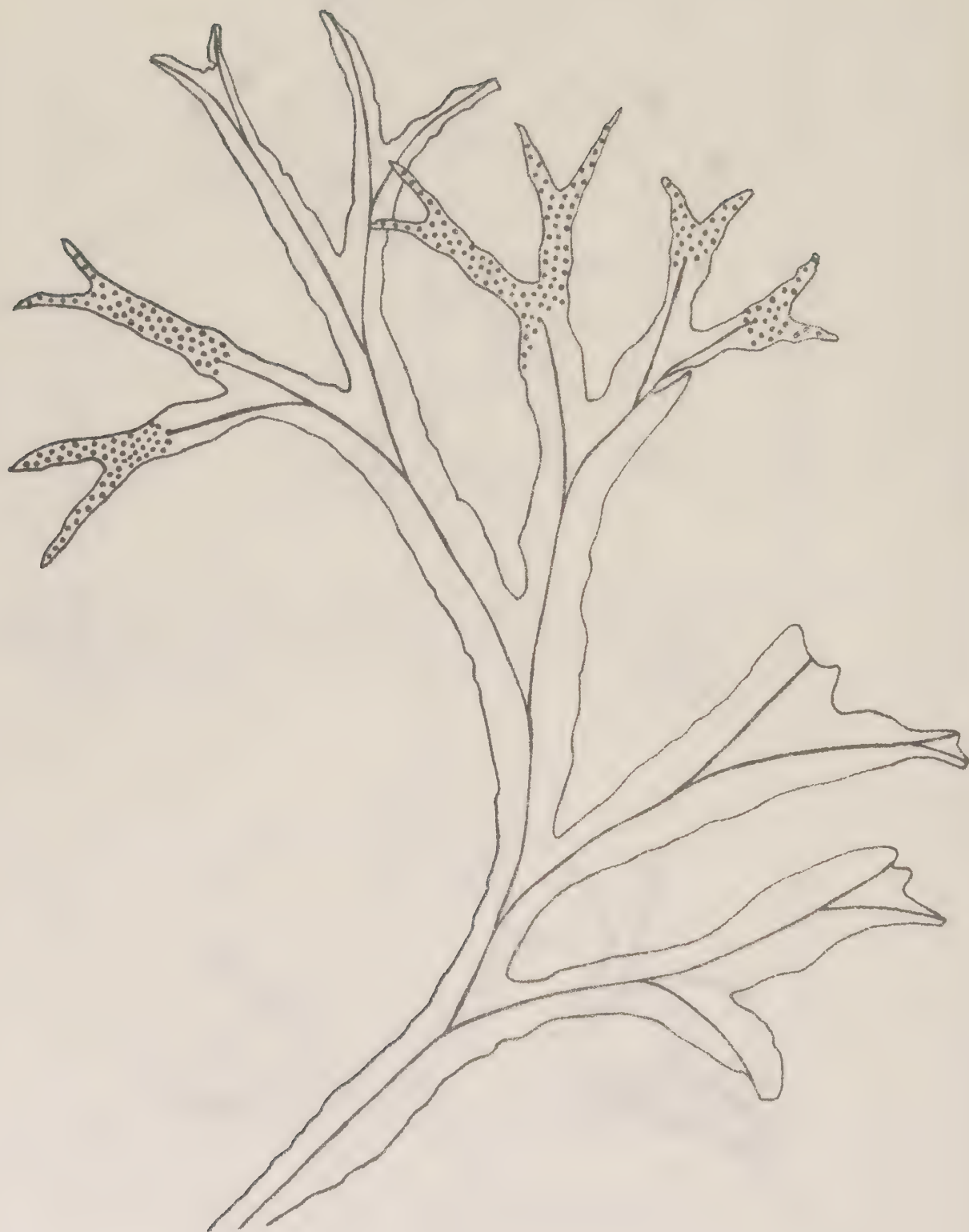


Fig. 114. A *Fucus hybrida* (x 0.1.) from Mairé 1907.

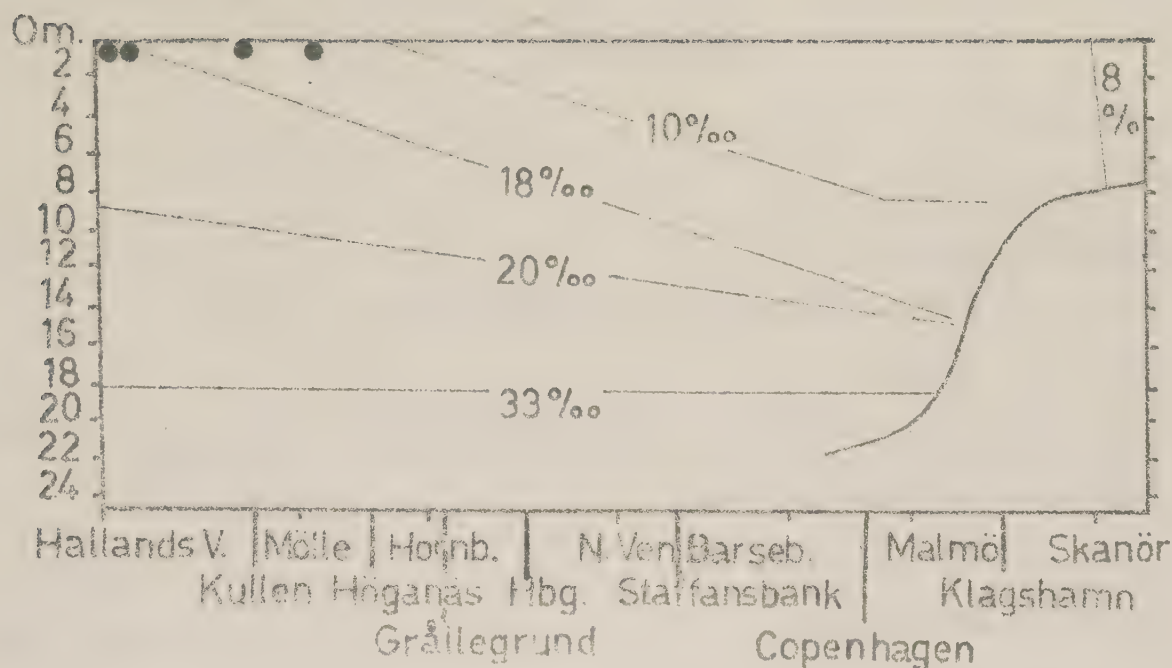


Fig. 115. The distribution of *Fucus spiralis* in relation to depth and salinity.

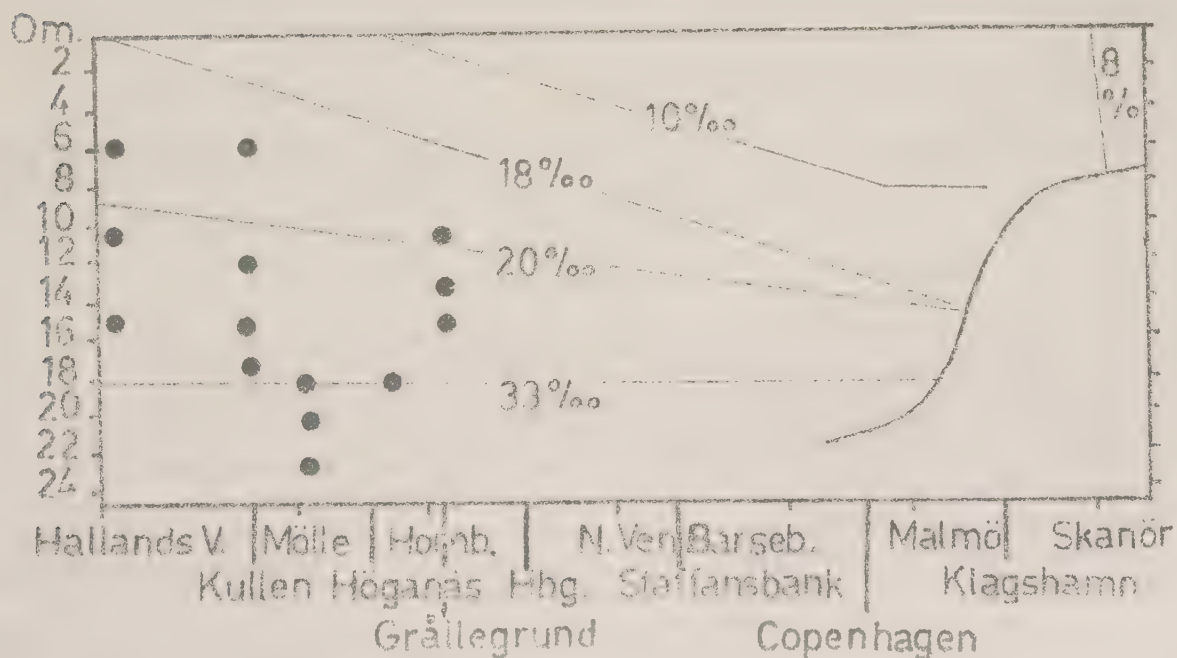


Fig. 116. The distribution of *Fucus spiralis* in relation to depth and salinity.

CHLOROPHYTA

CHLOROPHYCEAE

CHLOROCOCCALES

Chlorococcaceae

Sykidion droebakense Wille

Distribution Sweden: Bohuslän, Kristineberg, Kylin (1949).

Denmark: -

Some specimens found in a sample of *Ulothrix* sp. from Kullen in May 1970 agreed with the description of *Sykidion droebakense*, viz. rounded, ca. 7 - 10 μ in diameter and substipulated.

Locality: Kullen.

Polyhalobe meioeuryhaline.

Chlorochytrium cohnii Wright

Distribution Sweden: Bohuslän, Kristineberg, Kylin (1949); Blekinge, Levring (1940).

Denmark: -

This species has not been observed from the Öresund area.

Locality: -

Chlorochytrium dermatocolax Reinke

Distribution Sweden: Bohuslän and Halland, Kylin (1949); Kullen, Levring (1935); Malmö, Hylmö (1916); Blekinge, Levring (1940); Öregrund, Waern (1952).

Denmark: -

The information about the size of this species is very variable. Reinke (1889) gives values of 15 - 20 x 20 - 30 μ , Hylmö (loc.cit.) e.g. 42 x 68 μ and Levring (1940) 30 - 45 μ in diameter. This great variation in cell size makes one suspect that we are dealing here with different species. Furthermore, when the substratum for this alga is considered, the suspicion is strengthened. In the Baltic, north of Blekinge, the species is according to Waern (loc.cit.) in most cases only seen in the Sphacelariaceae. In the south part of the Baltic, along the Swedish west-coast and the Norwegian coast it is frequent in *Rhodomela* and *Polysiphonia* sp. In the Arctic Ocean the species is again found in different brown algae.

In the Öresund *Chlorochytrium dermatocolax* is only found on three occasions, twice at Kullen in *Polyides rotundus* and *Rhodomela confervoides* and once at Klagshamn in *Polysiphonia* sp., from 6 - 8 m in depth. In all cases the cells were 24 - 26 x 40 - 45 μ .

Localities: Kullen, Klagshamn.

Polyhalobe pleioeuryhaline.

Chlorochytrium inclusum Kjeiln.

Distribution Sweden: Kristineberg in *Polyides rotundus*, Levring (1935 b); Kristineberg in *Dilsea carnosa*, Kylin (1949).

Denmark: -

Jönsson (1962) has shown by culture experiments with *Spongomorpha aeruginosa* that this species has a heteromorphic life-cycle in which the zygote germinates into a form resembling *Chlorochytrium inclusum*. Kornmann (1961 b) has made observations in the same direction. The present author, however, is not convinced that *Spongomorpha aeruginosa* has a heteromorphic life-cycle in the Öresund region and, therefore, proposes to retain the species for the time being.

Chlorochytrium inclusum has only been found twice, both in the north part of the Öresund at depths of 6 m, in one case in *Polyides rotundus* and in the other in *Zostera marina*. In both cases the specimens were collected in spring and the cells measured ca. 60 x 80 μ .

Localities: Kullen, Ellekille Page.

Polyhalobe meliceuryhaline.

Gomontia polyrhiza (Lagerh.) Born. et Flah.

Distribution Sweden: Bohuslän, Kristineberg, Kylin (1949); Kullen, Levring (1935); Malmö, Hylmö (1916); Blekinge, Levring (1940).

Denmark: Kattegatt, Smålandsbanken, 1911, 1912.

This species is commonly found in the Öresund, mostly from depths of 1 - 5 m but even down to 15 m, in various mollusc shells, esp. *Cardium*, *Mya*, *Mytilus*, in bivalves and more seldom in *Spirorbis*. The cells are 50 - 100 x 150 - 200 μ . The species is observed throughout the year.

Localities: Common in the whole area.

Polyhalobe pleiceuryhaline.

Prasinocladus lubricus Kuck.

Distribution Sweden: Bohuslän, Kristineberg, Kylin (1949).

Denmark: Amager near Copenhagen, Christensen (1955).

This curious colonial green alga was once collected mixed with blue-green alga, inside the jetty of Gilleleje harbour just below the G-line, 16 February.

Locality: Gilleleje.

Polyhalobe mesoeuryhaline.

GLOTHRICALES

Glothrionaceae

Glothrrix acrophiza Kornm.

Distribution Sweden: -

Denmark: Copenhagen, Kornmann (1964).

This species was described by Kornmann (loc.cit.) from culture experiments. One of the cultures was derived from an *Acrosiphonia centralis*, collected by Christensen in the vicinity of Copenhagen. The species is morphologically indistinguishable from *Ulothrix subflaccida* and differs only in having sexual reproduction while *Ulothrix subflaccida* only reproduces by zoospores. It does not seem defensible to establish species on such grounds. At most it could be considered as an aberrant form of *Ulothrix subflaccida*.

Locality: -

Ulothrix consociata Wille

Distribution Sweden:

Denmark: Gilleleje, Christensen (1955).

The species has been found once in the north part of the Öresund at Gilleleje by Christensen (loc.cit.). The present author, however, has not been able to find it. After studies of dried material from Christensen's collections the author is not quite convinced that this is a case of the real *Ulothrix consociata*. It is probably a misshaped *Ulothrix* or possibly a species that ought to be placed in another genus.

Locality: -

Ulothrix pseudoflacca Wille

Distribution Sweden: Bohuslän and Halland, Kylin (1949); Kullen, Levring (1935); Malmö, Hylmö (1916); Blekinge, Levring (1940); Öregrund, Waern (1952).

Denmark: Kattegatt, Samsö, Smålandshavet, Öresund.

This species is intermingled with other *Ulothrix* and *Urospora* species of the green "Ulothrix - Urospora belt" which covers the littoral and parts of the supralittoral zones during spring and autumn, from 1 - 2 m above the 0-line and down to 0.25 m below. The green belt starts growing in January often together with *Bangia fuscopurpurea* and *Porphyra linearis*. When these species die in the middle of March, the green belt begins to grow vigorously. On one occasion the whole green belt was hit by cold weather in March and died away, but in April when the conditions were more favourable the belt became fully developed in 14 days. As a rule the whole green belt dies away at the beginning of June. A reduced green belt is usually seen from the middle of August to October - November in the north part of the area and in the south somewhat later, from September until December.

Ulothrix pseudoflacca is the most abundant of the *Ulothrix* species in the green belt and forms 25 - 30 % of the belt. It seems, however, to have a more restricted vertical distribution than *Ulothrix speciosa*. In most cases it is only found from ca. 0.25 m above to 0.25 m below the 0-line. The filaments of *Ulothrix pseudoflacca* are 4 - 7 cm long and the cells 9 - 10 x 7 - 16 μ . The species is mostly found from January to the beginning of June and from September to November and is fertile from March to June.

Localities: Common in the whole area.

Polyhalobe pleioeuryhaline.

Ulothrix speciosa (Carm. ex Harv. in Hook.) Kütz. sensu Kornm.

(*Ulothrix flacca* (Dillw.) Thur. in Le Jol.)

Distribution Sweden: Bohuslän and Halland, Kylin (1949); Kullen, Levring (1935).

Denmark: Kattegatt, Samsø, Öresund.

Ulothrix speciosa is always seen as a component of the green belt, distributed throughout the whole belt. It forms approximately 10 - 15 % of the green belt, a little lesser during autumn. There is no difference in the distribution of the species within the belt, neither in the vertical distribution nor in the time during the vegetation period.

The length of the filaments varies from 2 - 5 cm. The cells are 16 - 25 - (30) μ in diameter and 0.25 - 1 times as long. In some cases even larger cells have been seen. Normally the cell walls are about 0.1 - 0.2 μ thick but walls up to 15 μ have been seen at some localities with a high amount of nutrient salts, e.g. 100 - 400 μ g P - $\text{PO}_4/$ l. The cell walls tend to become thicker in the upper part of the green belt.

The species is found from January to the beginning of June and from September to December. It becomes fertile in March and continues until the beginning of June. When the filaments become fertile, they are heavily spiralized. This was also observed by Kornmann (1964) in cultures. The same phenomenon has also been noticed in *Urospora* by Hanic (1965).

Localities: Common down to Barsebäck; rather sparse from Barsebäck to Skanör.

Polyhalobe mesoeuryhaline.

Ulothrix subflaccida Wille

Distribution Sweden: Bohuslän and Halland, Kylin (1949); Kullen, Levring (1935); Malmö, Hylmø (1916); Blekinge, Levring (1940); Öregrund, Waern (1952).

Denmark: Samsø, Great Belt, Smålandshavet, Öresund, W.Baltic.

Ulothrix subflaccida is less abundant than the other species and forms 1 - 10 % of the green belt. Like *Ulothrix pseudoflacca*, *Ulothrix subflaccida* is most abundant in a narrow zone around the 0-line, ca. 0.2 m on each side.

The filaments are 4 - 5 cm long with cells 6 - 10 x 10 - 20 μ . However, in some cases cells 12 - 15 μ in diameter were found. The species is found from February to June and from September to December. It is fertile from March to June. Kornmann's (1964) observation in culture that the species matures and becomes fertile after about a fortnight at high temperature (about 15 °C) is clearly seen in May and June when many of the old filaments are more or less covered with small new filaments, 2 - 10 mm long. No fertile specimens have been found during autumn.

Localities: Abundant in the whole area.

Polyhalobe pleioeuryhaline.

ULVALES

Monostromataceae

Monostroma grevillei (Thur.) Witttr.

Distribution Sweden: Bohuslän and Halland, Kylin (1949); Kullen, Levring (1935);

Malmö, Hylmø (1916); Blekinge, Levring (1940).

Denmark: Kattegatt, Samsø, Smålandshavet, Öresund, Baltic Möen.

The species is commonly found throughout the whole area from 0.2 m below the 0-line down to 1 - 1.5 m. The Monostroma belt is most well developed and dense from 0.2 - 1 m below the 0-line. In the author's opinion *Monostroma grevillei* has rapidly increased in quantity during the last decade.

The maximum length of the monostromatic discs is ca. 10 - 12 cm and they are 2 - 6 cm broad. Small sail-like specimens are found from the middle of February and growth is vigorous during March. In April most specimens are torn away by the motion of the waves and either drift ashore or sink to the bottom. From the beginning of May very few specimens are seen. The species is fertile from the end of March to the end of April.

Locality: Common in the whole area.

Polyhalobe pleioeuryhaline.

Ulvaria oxysperma var. oxysperma (Kütz.) Bliding

(*Monostroma latissimum* (Kütz.) Wittr.)

Distribution Sweden: Bohuslän, Kristineberg, Kylin (1949); Barsebäck, Malmö, Hylmø (1916); Blekinge, Levring (1940).

Denmark: Kattegatt, Samsø, Smålandshavet, Öresund, W. Baltic, Baltic Möen.

Ulvaria oxysperma var. oxysperma is distributed in the whole Öresund area but in very varying abundance. It grows intermingled with *Monostroma grevillei* from 0.2 - 1 m below the 0-line. The specimens are very variable in size from 1 - 2 dm² up to 100 dm². Such big forms are not uncommon. The species is found during spring from the end of February until August. In April it is a rule torn away like the preceding species. But in contrast to this alga it can continue to grow in free-floating form in shallow waters in not too exposed bays, e.g. Lundåkra and Lomma Bays. At such localities huge amounts of free-floating specimens are found. It is fertile from April to August.

Localities: Höganäs, Lerherget, Helsingör, Råå, Sletten, Landskrona, Lundåkra Bay, Sjöbøbaden, Barsebäck, Bjärred, Lomma, Dragör.

Polyhalobe pleioeuryhaline.

Ulvaceae

Blidingia minima (Näg. ex Kütz.) Kylin

Distribution Sweden: Bohuslän and Halland, Kylin (1949); Kullen, Levring (1935); Malmö, Hylmø (1916); Blekinge, Levring (1940); Öregrund, Waern (1952).

Denmark: N. Kattegatt, Samsø, The Belts, Smålandshavet, Öresund, Baltic proper.

This species is common in the whole Öresund area though Levring (1935) considered it to be "ziemlich selten" at Kullen. It forms belts at exposed localities from 0.75 m above the 0-line down to 0.5 - 0.8 m below. It seems to be favoured by high amounts of nutrient salts and is very common at polluted localities, except in the vicinity of Malmö, where the species has disappeared during the last

decade.

The specimens are 5 - 7 cm long and 3 - 4 - (5) mm broad. The species is found throughout the year. Growth begins in the end of February and is vigorous in March to June. During summer with low water level and high temperatures the specimens in the supralittoral zone are partly killed. During autumn, September - November, growth begins again and a new generation of *Blidingia minima* is seen. From December most specimens decay and in January only a few specimens are seen. Fertile specimens are found from February to December.

Localities: Common in the whole area.

Polyhalobe pleioeuryhaline.

Capsosiphon fulvescens (C. Ag.) Setch. et Gardn.

Distribution Sweden: Bohuslän and Halland, Kylin (1949); Kullen, Levring (1935); Malmö, Hylmö (1916); Blekinge, Levring (1940); Öregrund, Waern (1952).

Denmark: Kattegatt, Samsö.

The species was originally described by C. Ag. on material from Landskrona and he later found it in Lomma Bay. Hylmö (loc.cit.) reported the species from Barsebäck, Malmö and Limhamn. Sjöstedt (1927) found it at Hallands Väderö and Levring (1935) observed one specimen at Kullen. The species has apparently been frequent in the Öresund. The author, however, has caught it again for the species. It has only been found once growing near a sewage outlet at Mölle. According to Bliding (1963), among others, the species thrives in polluted and brackish waters. It may be favoured by high amounts of nutrient salts but is probably sensitive to toxic compounds from industrial wastes.

Locality: Mölle.

Polyhalobe pleioeuryhaline.

Enteromorpha ahneriana Bliding

Distribution Sweden: Bohuslän and Halland, Kylin (1949); Kullen, Levring (1935); Blekinge, Levring (1940); Öregrund, Waern (1952).

Denmark: Öresund.

This species is commonly found at semi-exposed to sheltered localities in the littoral zone in a narrow, dense belt, often growing on jetties, pebbles and to some extent also on *Fucus*. It seems in contrast to *Enteromorpha compressa* to be most abundant in heavily polluted areas in the Öresund. The slender, heavily branched thalli are 25 - 30 cm long and found from April to November.

Localities: Common in the whole area.

Polyhalobe pleioeuryhaline.

Enteromorpha clathrata (Roth) Grev.

Distribution Sweden: Bohuslän and Halland, Kylin (1949); Kullen, Levring (1935); Malmö, Hylmö (1916); Blekinge, Levring (1940); Öregrund, Waern (1952).

Denmark: -

This is, besides *Enteromorpha ahlfneriana* and *Enteromorpha intestinalis*, the most common *Enteromorpha* species in the Öresund area. *Enteromorpha clathrata* is found in the littoral zone as well as in low-lying rock-pools in belts together with *Enteromorpha intestinalis*. It is also found growing at sheltered positions on fucoids. The length of the thalli is 15 - 20 cm. Growth begins in April and the vegetation period ends in October, though in a few cases specimens have also been found from October to March.

Localities: Common in the whole area.

Polyhalobe pleioeuryhaline.

Enteromorpha compressa (L.) Grev.

Distribution Sweden: Bohuslän and Halland, Kylin (1949); Kullen, Levring (1935); Malmö, Hylmö (1916); Blekinge, Levring (1940); Öregrund, Waern (1952).

Denmark: -

Enteromorpha compressa has an irregular distribution in the Öresund. At some places it is fairly common while at others it is missing. It grows at moderately exposed to sheltered localities from 0 - 1 m in depth and can also be found detached in large amounts in shallow bays. The author is of the opinion that it doesn't thrive very well at heavily polluted localities where it seems to be overgrown by *Enteromorpha intestinalis*. Growth begins in April and fully developed specimens, 20 - 30 cm long and 0.7 - 1.2 cm broad, are found from the end of May to September.

Localities: Frequent - sparse in the whole area.

Polyhalobe pleioeuryhaline.

Enteromorpha intestinalis (L.) Link

Distribution Sweden: Bohuslän and Halland, Kylin (1949); Kullen, Levring (1935); Blekinge, Gjöstedt (1928 a); Malmö, Hylmö (1916); Blekinge, Levring (1940); Öregrund, Waern (1952).

Denmark: N. Kattegatt, Great Belt, Smålandshavet, Öresund, W. Baltic, Baltic Möen.

This species is very common throughout the Öresund and forms belts from 1 m above the 0-line to 0.4 m below. Single specimens are found down to 3 m in depth. At very exposed localities the belt is situated above the 0-line and at moderately and sheltered localities from the 0-line to 1.0 - (0.5) m in depth.

The specimens vary in length and breadth according to the degree of exposure and eutrophication. Thus, at very exposed localities specimens are 0.3 - 0.5 x 5 - 8 cm whereas at more sheltered localities they are 1 - 3 x (10) - 20 - 50 - (70) cm due to the amount of available nutrient salts. At some very sheltered and eutrophicated localities specimens 10 - 12 cm broad and 1.5 m long have been observed.

The species seems to have two or three consecutive generations during the year. Growth begins in January, is vigorous in February and March and often retarded during the period of low water in March and April. Toward the end of the summer most specimens seem to die and are succeeded by a new generation in September. The growth during November and December is relatively low. Whether these specimens continue to grow during spring or are succeeded by a new generation is hard to say. Most probably both can happen. The species is "hardy" at low temper-

natures but seems to be injured or killed during low water periods.

Localities: Common in the whole area.

Polyhalobe pleioeuryhaline.

Enteromorpha linza (L.) J. Ag.

Distribution Sweden: Bohuslän and Halland, Kylin (1949); Kullen, Levring (1935); Malmö, Hylmö (1916).

Denmark: N. and middle Kattegatt, Samsö, Little Belt, Smålandshavet, Öresund, Baltic Möen.

This species which according to Levring (loc.cit.) "kommt --- ziemlich all-gemein vor" and according to Hylmö (loc.cit.) "sehr häufig" has apparently decreased in abundance during recent decades. Today it is irregularly found in the area. The only area where it is abundantly found is in the northernmost part. It grows at semi-exposed localities on stones and fucoids. The thalli are as a rule 7 - 15 cm long and 2 - 5 cm broad near the apex. The vegetation period is from late April to September.

Localities: Abundant at Hovs Hallar, Torekov, Hallands Väderö, Kullen; frequent otherwise.

Polyhalobe mesoeuryhaline.

Percursaria percursa (C. Ag.) Rosenv.

Distribution Sweden: Bohuslän and Halland, Kylin (1949); Kullen, Levring (1935); Båstad, Hylmö (1916); Blekinge, Levring (1940); Öregrund, Wärn (1952).

Denmark: N. and middle Kattegatt, Samsö.

Percursaria percursa is common along the coasts of the Öresund on sandy shore-meadows where it grows as a thin green carpet on the soil, often together with *Rhizoclonium riparium*. The filaments are (20) - 24 - 36 μ broad and the cells about (10) - 12 - 18 x 12 - 24 μ . The cell size is variable and the major part of the material varies around the lower values. The species is found throughout the year, but the main growth occurs from March to May and in September to October. Fertile specimens are found from April to September.

Localities: Common in the whole area.

Polyhalobe pleiosuryhaline.

Ulva lactuca L.

Distribution Sweden: Bohuslän and Halland, Kylin (1949); Malmö, Hylmö (1916); Lomma, Weibull (1919).

Denmark: Kattegatt, Samsö, Smålandshavet, Baltic Möen; Öresund, Ørsted (1844).

Ulva lactuca was first mentioned from the Öresund in Ørsted (loc.cit.): "Ulva lactuca quibus praecipue sinus cum fundo limoso abundant, velut in Kallebodstrand, inter Havniam et Tre Kroner, ad Landskronam". Hylmö (loc.cit.) considers this species to be "häufig" in the neighbourhood of Malmö and found large specimens from 0.5 - 1 m² in area at Limhamn. Weibull (loc.cit.) states that the



Fig. 117. The distribution of *Ulva lactuca*.

- finds 1960 - 1972
- finds 1950 - 1959

species had become very abundant from 1909 - 1916 and dominated the algal flora of Lomma Bay. The species was, besides *Zostera marina*, the main constituent of the seaweed banks on the shores. He also connected this with the start of the domestic sewage outlets of Malmö.

During the first part of the 1960s the author found *Ulva lactuca* in small amounts in different parts of the Öresund, e.g. Mölle, Lerhamn, Nyhamnsläge, Lerberget, Ven, Landskrona, Skogshoved, Saltholm and Köge. During the latter years of the 1960s and up till now the species has only been found at one locality: Norrebro at the island of Ven.

Ulva lactuca has been found in the Öresund in both the attached form, *f.stipitata*, and the loose-lying form, *f.latissima*. The attached form has mainly been found in the north part of the area and the loose-lying form in the south part. The attached form is mainly found in a belt about 0.25 - 0.5 m below the 0-line. *Ulva lactuca* has very little ability to compete with other algae and is mainly found on ice-scraped stones where it is soon replaced by other algae. The loose-lying form is mostly found in shallow waters, 0 - 0.5 m deep, but in some cases the author has found single specimens down to about 8 m in depth. The species has been found throughout the year but mostly from March to October.

Localities: 1960 - 65, attached form: Arild, Kullen, Mölle, Lerhamn, Nyhamnsläge, Höganäs, Lerberget, Gilleleje.

1960 - 65, loose-lying form: Norrebro, Landskrona, Sjöbobaden, Skogshoved, Saltholm, Köge.

1967 - 72, loose-lying form: Norrebro. (Fig. 117)

Polyhalobe mesoeuryhaline.

PRASIOALES

Prasiolaceae

Prasiola stipitata Suhr in Jessen

Distribution Sweden: Bohuslän and Halland, Kylin (1949); Kullen, Levring (1935); Malmö, Hylmö (1916); Blekinge, Levring (1940); Öregrund, Waern (1952).

Denmark: N. and E. Kattegatt, Samsø, Smålandshavet, Öresund.

This species is abundantly found in the supralittoral zone from just above the 0-line up to 2 m high, either on "bird-tops" or at polluted localities near sewage outlets. The species is variable from broad fan-shaped to very narrow thalli Fig. 118 A-B. The size is also variable and correlated with the grade of pollution. Normal specimens are 2 - 3 mm long and 1 - 2 mm broad. At very polluted localities they can be 6 - 7 mm long and 4 - 6 mm broad. The species is found during the whole year and growth takes place from February to May and from September to November. During summer the growth is retarded and some of the specimens seem to die. No sexual reproduction has been observed, as was reported by Friedmann (1959), but reproduction by asexual cysts takes place during the whole year, especially when the specimens begin to dry.

Localities: Abundant in the whole area.

Polyhalobe pleioeuryhaline.

Rosenvingiella polyrhiza (Rosenv.) Silva

(*Gayella polyrhiza* Rosenv.)

Distribution Sweden: Bohuslän, Waern (1952) and Söderström (1965); Kullen, Lev-

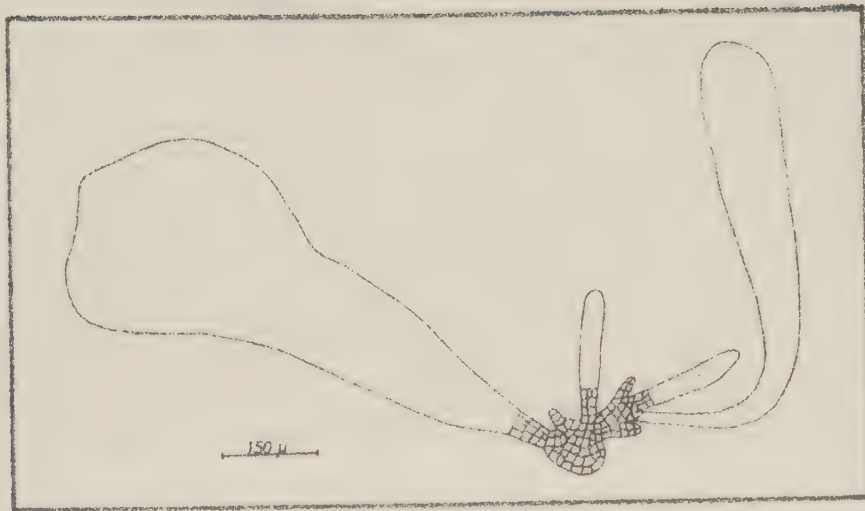


Fig. 118 A. From Mölle.

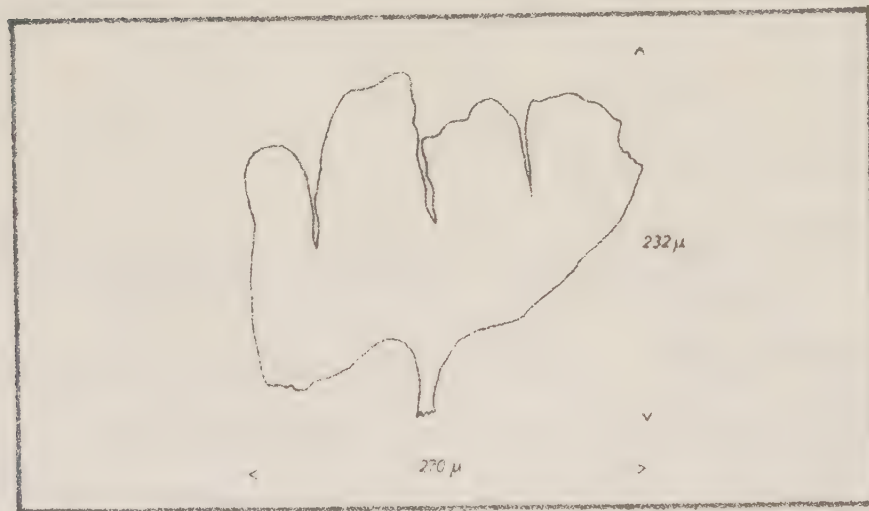


Fig. 118 B. From Barsebäck.

Fig. 118 A - B. *Phasiola stipitata*.

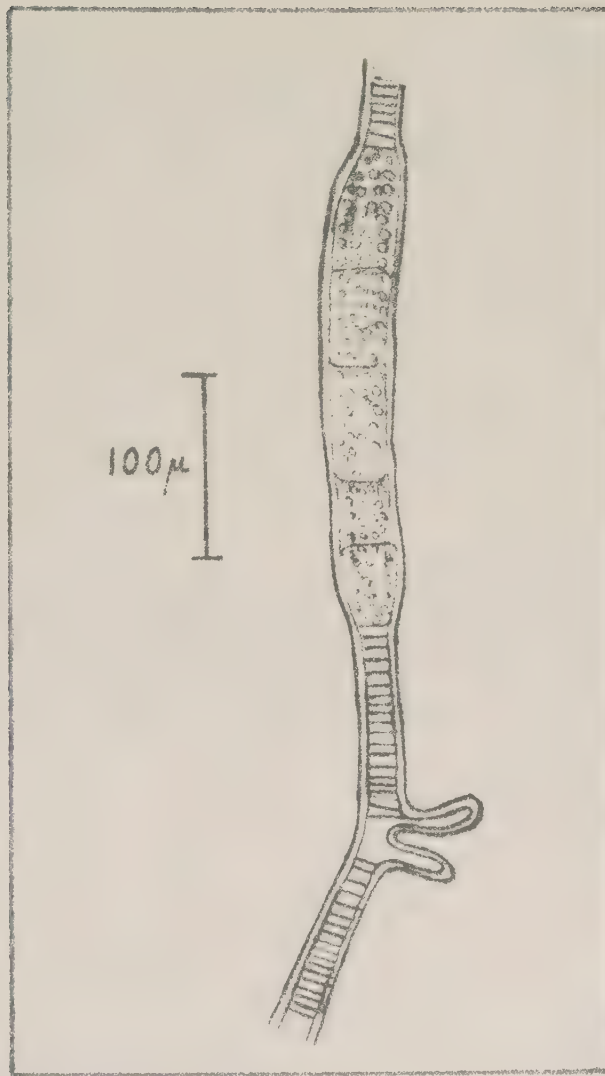


Fig. 1.1. *Piscolingulus* sp. (100μ scale bar).
from M. 12.

ring (1935); Barsebäck, Hylmö (1916); Blekinge, Levring (1940); Öregrund, Waern (1952).

Denmark: Kattegatt, Samsö, Baltic Möen; Copenhagen, Kristiansen (1972).

This species was originally described as *Prasiola crispa* Lightf. f. *submarina* Wille. The question whether *Rosenvingiella polyrhiza* is only a stage in the development of *Prasiola crispa* or an independent genus has been controversial for a long time. Waern (loc.cit.) discusses this question in detail and comes to the conclusion that the genus *Rosenvingiella* ought to be maintained. *Prasiola crispa* has not been found at all in the Öresund. *Rosenvingiella polyrhiza* often but not always grows together with *Prasiola stipitata*. One could, therefore, suspect that there are some connections between these two species. Friedmann (1959) considered that he had found a *Rosenvingiella* stage in his cultures of *Prasiola stipitata*. The author has never found any transitional stages between *Rosenvingiella polyrhiza* and *Prasiola stipitata*, either in culture or in nature.

Levring (1935) stated that he found *Rosenvingiella polyrhiza* "nur bei einer Gelegenheit" and Hylmö (loc.cit.) found the species once in Barsebäck. Today the species is abundant in the whole Öresund area. It grows in the supralittoral zone from 0.2 m to 5 - 6 m above the 0-line, the upper limit coinciding quite well with the lower limit of *Caloplaca marina*. The increased appearance of the species since earlier investigations may be an effect of the increased pollution. According to Knebel (1935) *Rosenvingiella polyrhiza* should be favoured by high levels of phosphorus and nitrogen.

The filaments vary in thickness from 9 - 30 μ and are about 1 - 2 cm long with frequent rhizoids. The species is found throughout the year. Growth starts in January to February and most of the filaments are dried during summer. Growth begins again in September to December. During winter *Rosenvingiella polyrhiza* forms a dense covering on stones. In spring the cover is usually not so thick. *Gayella* formations have been observed most frequently from March to May (Fig. 119).

Localities: Abundant in the whole area.

Polyhalobes pleioeuryhaline.

CHAETOPHORALES

Chaetophoraceae

Acrochaete parasitica Oltm.

Distribution Sweden: Bohuslän, Kristineberg, Kylin (1949); Kullen, Levring (1935); Malmö, Hylmö (1916); Blekinge, Levring (1940); Gotland, Svedelius (1901); Öregrund, Waern (1952).

Denmark: -

This species has been frequently found in the whole area from 0.5 - 1.5 m in depth, growing on *Fucus serratus* and *Fucus vesiculosus* together with *Pseudopringsheimia fucicola*. Although Svedelius (1901) also observed this species on *Zostera* leaves, this has not been the case in the Öresund. Specimens have been observed during February to April. Fertile specimens have been found on a few occasions in March and April.

Localities: Kullen, Gilleleje, Helsingör, Barsebäck, Klagshamn, Falsterbo.

Polyhalobes pleioeuryhaline.

Acrochaete repens N. Pringsb.

Distribution Sweden: Bohuslän, Kristineberg, Kylin (1949); Kullen, Levring (1935); Malmö, Hylmö (1916); east Scania, Kivik, Sjöstedt (1920); Blekinge, Levring (1940); Öregrund, Waern (1952).

Denmark: Smålandshavet.

Acrochaete repens is said to be a facultative epiphyte on *Chorda filum*, Huber (1892), Kylin (loc.cit.) and Waern (loc.cit.). However, Waern (loc.cit.) mentions the species from *Stictyosiphon*.

The species is sparsely found in the Öresund from 0.5 - 6 m in depth on *Chorda filum* and *Halosiphon tomentosus*. The author has also found small green epiphytes both on *Ectocarpus* and *Pilayella* sp. which are identical with such found on *Chorda filum* and *Halosiphon tomentosus*. The species is found throughout the year, but only a few specimens at a time, with one exception in May in the south part of the Öresund (Klagshamn) where it was abundant on *Ectocarpus* and *Pilayella* sp. Fertile specimens have been found from May to October.

Localities: Kullen, Grälleggrund, Ven, Klagshamn.

Polyhalobe pleioeuryhaline.

Bolbocoleon piliferum N. Pringsh.

Distribution Sweden: Bohuslän and Halland, Kylin (1949); Kullen, Levring (1935); Malmö, Hylmö (1916); Blekinge, Levring (1940); Gotland, Ridelius (1933); Öregrund, Waern (1952).

Denmark: N. Kattegatt, Smålandshavet.

Bolbocoleon piliferum according to the literature is said to be common along the Swedish west-coast, Kylin (loc.cit.), as well as in the Öresund, Levring (1935), Hylmö (loc.cit.) and in the Baltic, Levring (1940), Ridelius (loc.cit.). Waern (loc.cit.) "has sought in vain for it" in the Öregrund archipelago except one find. He points out that *Aphanochaete repens* could have been misinterpreted for *Bolbocoleon piliferum* in the Baltic.

In the Öresund the present author has looked for this species in a large material but only found it on two occasions, at Kullen in the beginning of September and at Ven in the middle of October, both times collected near the O-line in *Nemalion multifidum*. It is possible that *Bolbocoleon piliferum* in the Öresund has become less abundant.

Localities: Kullen, Ven.

Polyhalobe pleioeuryhaline.

Ectochaete leptochaete (Huber) Wille

Distribution Sweden: Halland, Varberg, Kylin (1949); Blekinge, Levring (1940); Öregrund, Waern (1952).

Denmark: -

This alga, which has been observed in Sweden only a few times, is undoubtedly very rare in Scandinavian waters. There also seem to be very few observations of the species from Norway. It is mentioned by Iylen & Jerde (1934).

The author has found the species a few times in the Öresund from 1 - 10 m in depth in different *Cladophora* sp., where it grows in the cell walls, either as filaments or sometimes as monostromatic discs. Only the best developed discs

seem to bear hairs. The cells measured $8 - 13 \times 10 - 25 \mu$. Only on one occasion in the end of August has fertile material been seen.

Localities: Kullen, Grållegrund, Ven, Barsebäck, Klagshamn.

Polyhalobe pleioeuryhaline.

Ectochaete wittrockii (Wille) Kylin

Distribution Sweden: Bohuslän and Halland, Kylin (1949); Kullen, Levring (1935); Malmö, Hylmö (1916); Blekinge, Levring (1940); Öregrund, Waern (1952).

Denmark: Little Belt, W. Baltic.

This species is undoubtedly fairly common along the Swedish west-coast. "gemein", Kylin (loc.cit.), and is frequently found in the south parts of the Baltic, but Waern (loc.cit.) mentioned just a few finds at Öregrund. From the north parts of the Sound Levring (1935) says, "sie kommt gemein in den Zwillwänden von *Filicella littoralis* and *Ectocarpus*-Arten vor". Hylmö (loc.cit.) referring to the south parts of the Öresund states: "im Sund dagegen ist sie sehr häufig. Es ist z.B. schwer, alte Exemplare von *Filicella* zu finden, die am Endodermis ganz frei sind".

Apparently there has been a change in the abundance of this species during the last decades. The author has looked through a large algal material from the Öresund but the finds of *Ectochaete wittrockii* are very limited. The species has been found from 0 - 12 m in depth in *Ectocarpus* sp., *Elachista indica*, *Phaeonematella fasciculata*, *Pilayella littoralis*, *Pilayella rupicola* and on a very few occasions in *Polysiphonia urceolata*. The cells are $8 - 12 \mu$ broad and $15 - 21 \mu$ long. The finds are made during the whole year but are most abundant from June to October. Fertile specimens have been seen from June to August.

Localities: A few finds in most localities.

Polyhalobe pleioeuryhaline.

Entocladia perforans (Huber) Levring

Distribution Sweden: Bohuslän and Halland, Kylin (1949); Kullen, Levring (1935); Malmö, Hylmö (1916); Blekinge, Levring (1940); Gotland, Svedelius (1921); Öregrund, Waern (1952).

Denmark: Smålandshavet.

Both Levring (1935) and Hylmö (loc.cit.) considered this species to be common in the Öresund region. The author, however, has surveyed a large material of living and dead *Zostera* leaves and only found the species on a few occasions in *Zostera* leaves dredged from 2 - 8 m in depth from March to October. Each *Zostera* cell seems to contain several *Entocladia perforans* cells which measured $8 - 12 \times 18 - 30 \mu$. Rows of cells often begin with a rounded cell and the following cells are elongated up to three times the diameter. No fertile specimens have been observed.

Localities: Ellekilde hage, Gräsrönan, Barsebäck, Åge.

Polyhalobe pleioeuryhaline.

Entocladia tenuis Kylin

Distribution Sweden: Bohuslän, Kristineberg, Kylin (1935, 1949); Blekinge, Levring (1940).

Denmark: N. and middle Kattegatt.

The delimitation between *Entocladia tenuis* and *Entocladia testarum* is not clear. The only real difference according to Kylin (1935) should be the behaviour of the germinating zoospore, which in *Entocladia tenuis* elongates into a germination tube before the branches are developed. In *Entocladia testarum* no germination tube is found. The two species grow together. The author has studied a large material of *Entocladia* and found transitional stages between *Entocladia tenuis* and *Entocladia testarum*. Therefore, the author is of the opinion that the separation into two species on such vague grounds is not possible.

Entocladia tenuis is abundantly found from 1 - 6 m in depth in mollusc shells, such as *Cardium* sp., *Mya* sp. and in old balanids. It is often found together with *Conchocelis*, *Gomontia polyrhiza* and *Ostreobium quekettii*. The cells in the observed material are 2 - 4 - (8) x 8 - 24 μ . Specimens are observed throughout the year but no fertile specimens have been found.

Localities: Hallands Väderö, Kullen, Gilleleje, Grållegrund, Barsebäck, Skanör.

Polyhalobe pleioeuryhaline.

Entocladia viridis Reinke

Distribution Sweden: Bohuslän and Halland, Kylin (1949); Kullen, Levring (1935); Blekinge, Levring (1940); Öregrund, Waern (1952).

Denmark: -

Entocladia viridis is one of the most common endophytes in the Öresund area. It is found from 0 - 25 m in depth and most prominent in red algae, such as *Amphifolia plicata*, *Teraxium rubrum*, *Gomontia incrassata*, *Odonthalia dentata*, *Polysiphonia elongata*, *Polysiphonia nigrescens*, *Polysiphonia urceolata* and *Polysiphonia violacea* and brown algae, e.g. *Sphacelaria cirrosa*.

Kylin (1938) pointed out the large diversity of descriptions and observations of the cell size of *Entocladia viridis* and, therefore, considered it to be a "collective" species. In the author's material of *Entocladia viridis* the variation in cell size is 3 - 8 x 10 - 30 μ . This phenomenon could either depend on an adaptation to the space between the "host cells" or that different species are involved. The species is found throughout the whole year. Fertile specimens are not common but have been seen from April to October.

Localities: Common in the whole area.

Polyhalobe pleioeuryhaline.

Epicladia flustrae Reinke

Distribution Sweden: Bohuslän and Halland, Kylin (1949); Kullen, Levring (1935); Malmö, Jylmø (1916); Blekinge, Levring (1940); Öregrund, Waern (1952).

Denmark: N. Kattegatt.

Even if this species is rather small and endozoic in different bryozoans

and sertularians, it is usually no problem to find it in nature without microscopic examination. In spite of the author having surveyed a large material of bryozoans and sertularians in order to look for *Epicladia flustrae*, it has only been found on two occasions at Kullen from 10 - 15 m in depth. According to Levring (1935), "kommt allgemein das ganze Jahr hindurch vor", and Hylmö (loc.cit.), "auf *Membranipora membranacea* im März beobachtet". Undoubtedly the species has become less abundant in the Öresund during the last decade.

Locality: Kullen.

Polyhalobe pleioeuryhaline.

Eugomontia sacculata Kornm.

Distribution Sweden: Bohuslän, Tjörnö, Kristineberg, von Wachenfeldt (unpubl.).

Denmark: N. and middle Kattegatt.

This little lime-boring alga was long misinterpreted as a part of *Gomontia polyrhiza*. Kylin (1935) was already aware of this. Kornmann (1959, 1960) demonstrated after careful culture studies that Kylin's opinion was correct and established the new genus *Eugomontia*.

The author has found *Eugomontia sacculata* to be common in the whole area, mainly from 0 - 6 m in depth. A few finds have been made down to 15 m in depth. The species grows together with *Gomontia polyrhiza* in mollusc shells, such as *Cardium*, *Macoma*, *Mya* and in balanids and more seldom in *Pomatoceros* and *Spirorbis*.

Localities: Common in the whole area.

Polyhalobe pleioeuryhaline.

Phaeophila engleri Reinke

Distribution Sweden: Bohuslän, Kristineberg, Kylin (1949); Blekinge, Levring (1940).

Denmark: N. and middle Kattegatt.

This endozoic alga has been met with on a few occasions from 1 - 5 m in depth, mostly in mollusc shells together with i.a. *Entocladia tenuis*. On one occasion the author accidentally found the species growing on a concrete block. In spite of the few records of this alga it is probably not uncommon in the area but it is easy to overlook. The find of the alga on a concrete block supports this hypothesis. The cells were 8 - 12 μ broad and 3 - 5 times longer. All specimens examined contained some papilla-bearing cells. Fertile specimens have been found during May to August.

Localities: Kullen, Gilleleje, Helsingborg, Barsebäck.

Polyhalobe pleioeuryhaline.

Pringsheimiella scutata (Reinke) Marchew.

Distribution Sweden: Bohuslän and Halland, Kylin (1949); Kullen, Levring (1935); Malmö, Hylmö (1916); Blekinge, Levring (1940); Öregrund, Waern (1952).

Denmark: S. Kattegatt, Smålandshavet.

This species is a fairly common epiphyte from 1 - 27 m in depth on many red

algae, e.g. *Ceramium* sp., *Cystoclonium purpureum* and *Polysiphonia* sp. and is probably most frequent on *Rhodomela confervoides*. The monostromatic discs are approximately 180 - 300 μ in diameter. The species has been found throughout the year but most frequently from May to October. Fertile specimens have been seen from June to September.

Localities: Abundant in the whole area.

Polyhalobe pleioeuryhaline.

Pseudendoclonium submarinum Wille

Distribution Sweden: Bohuslän and Halland, Kylin (1949); Kullen, Levring (1935); Barsebäck, Hylmö (1916); Blekinge, Levring (1940); Öregrund, Waern (1952).

Denmark: N. and middle Kattegatt, Öresund.

This wood-growing alga is widely distributed in the Öresund area. It is common in exposed localities from about 1 - 2 m above the 0-line to about 2 m below. Waern (loc.cit.) has recorded the species on stones and in rock-pools in the Baltic, and Pankow (1971) has observed the species on different algae too. The species is seen throughout the year.

Localities: Common in the whole area.

Polyhalobe pleioeuryhaline.

Pseudoprinkeimia fucicola (Kütz.) Wille

Distribution Sweden: Bohuslän, Kristineberg, Kylin (1949); Kullen, Levring (1935); Hylmö, Kylin (1949); Blekinge, Levring (1940); Öregrund, Waern (1952).

Denmark: Smålandshavet.

This species seems to be fairly common in the whole area though Levring (1935) states "nur ein paarmal und im März angetroffen", and Hylmö (loc.cit.) "keine im April beobachtet". It is impossible to say whether the species really has become more abundant during the last decades. The species has been found from 1 - 2 m in depth on *Ascophyllum nodosum*, *Fucus serratus* and *Fucus vesiculosus*. *Pseudoprinkeimia fucicola* is sometimes seen growing together with *Acetabularia medusullica*. The species is usually easy to discover in the field as small, light green cushions. The specimens are found during spring (February - April).

Localities: Abundant in the whole area.

Polyhalobe pleioeuryhaline.

Ulvella lens Crouan frat.

Distribution Sweden: Bohuslän, Väderöarna, Kristineberg, Kylin (1907); Kullen, Levring (1935).

Denmark: -

This species is mentioned by Kylin (loc.cit.) and Levring (loc.cit.) from the Swedish coast. Kylin (1907), however, is doubtful if the observed specimens really belong to *Ulvella lens*.

The author has collected a few *Ulvella*-like small green crusts in Kristineberg (Bohuslän) and once in the north part of the Öresund in the same locality as mentioned by Levring (loc.cit.). The variation in size and form, however, in the observed material is too large to permit identifying it for certain as *Ulvella* lens. Furthermore, many green algae have a juvenile stage which is similar to *Ulvella* lens. The author is, therefore, not convinced that these crusts really can be referred to *Ulvella* lens.

Locality: Kullen?

Polyhalobe meioeuryhaline?

Chrooclepidaceae

Pilinia rimosa Kütz.

Distribution Sweden: Bohuslän, Väderöarna, Kristineberg, Kylin (1949).

Denmark: -

The species has been found on one occasion: a few specimens were growing at Kullen in July 1966 on a very exposed stone near the 0-line on and between *Balanus* sp. The specimens consisted of small cushions with few very sparsely branched erect filaments. The filaments were 160 - 250 μ long and the cells measured 4 - 8 x 6 - 16 μ . All filaments were sterile.

Locality: Kullen.

Polyhalobe meioeuryhaline.

Tellamia contorta Batt.

Distribution Sweden: Bohuslän, Kristineberg, Kylin (1949).

Denmark: -

Within this species the author has brought together all specimens of *Tellamia* which have been seen in the Öresund. It seems unlikely that the small difference given in Batters (1895) descriptions and the wide variation in the material, e.g. in cell size, could justify a separation into two species. Printz (1926) and Levring (1937) have also suggested that the two species have to be united.

Tellamia contorta s.l. has been found in the north part of the Öresund from 0 - 2 m in depth on *Littorina obtusata*. The cells in the observed material were 4 - 7 x 3 - 15 μ .

Localities: Hovs Hallar, Hallands Väderö, Kullen, Gilleleje.

Polyhalobe meioeuryhaline.

CLADOPHORALES

Cladophoraceae

Chaetomorpha aerea (Good. ex Dillw.) Kütz.

Distribution Sweden: Bohuslän and N. Halland, Kylin (1949); Kullen, Levring (1935).

Denmark: -

The genus *Chaetomorpha* is in urgent need of revision. The limits between the different species are not quite clear, Waern (1952). This is especially obvious in the *Chaetomorpha aerea-linum* complex. Rosenvinge (1894) pointed out that *Chaetomorpha aerea* and *Chaetomorpha linum* are two forms of the same species. Furthermore, the status of *Chaetomorpha baltica* Kütz., *Chaetomorpha capillaris* (Kütz.) Börgesen, *Chaetomorpha chlorotica* (Mont.) Kütz. and *Chaetomorpha gracilis* Kütz. are uncertain. Christensen (1957) considered *Chaetomorpha aerea* and *Chaetomorpha linum* to be conspecific. According to Kessler (1959) *Chaetomorpha capillaris* and *Chaetomorpha gracilis* belong to *Chaetomorpha linum* and on the other hand *Chaetomorpha baltica* and *Chaetomorpha chlorotica* are forms of *Chaetomorpha aerea*. Kornmann (1972) has shown by culture studies that *Chaetomorpha aerea* and *Chaetomorpha linum* really are two distinctly separated species.

In the material from the Öresund the distribution of the typical *Chaetomorpha aerea* is restricted to the north part of the area. Normally this species can be found regularly in small patches at Hallands Väderö and at the north side of Kullen. In the Öresund proper it has only been met with on a few occasions at Lerhamn. The irregular appearance at Lerhamn is most probably due to the fluctuating salinity. During periods of somewhat higher salinity than normal zoospores from Kattegatt can germinate. *Chaetomorpha aerea* should accordingly be meioeuryhaline. It is not probable that two forms of the same species behave differently to low salinity, in other words that the attached form (= *Chaetomorpha aerea*) is meioeuryhaline and that the loose-lying form (= *Chaetomorpha linum*) is pleioeuryhaline. *Chaetomorpha aerea* is found at exposed places in a narrow belt about 0.1 m broad just around the O-line. The threads are in most cases not more than 5 cm long, light green and very rigid. The cells are 150 - 350 x 300 - 600 μ . Specimens have been found throughout the year and fertile individuals from January to September.

Localities: Hallands Väderö, Kullen, Lerhamn.

Polyhalobe meioeuryhaline.

Chaetomorpha linum (O.F. Müll.) Kütz.

Distribution Sweden: Bohuslän and Halland, Kylin (1949); Barsebäck, Hylmö (1916); W. Malmö, Waern (1965 a); Blekinge, Levring (1940); Öregrund, Waern (1952).

Denmark: N. and S. Kattegatt, Samsö, The Belts.

In the Botanical Museum in Lund there are some finds of *Chaetomorpha linum* by Hylmö from Kullen, Mölle and Barsebäck. The author has only found the species in the southernmost part of the Öresund.

Locality: The canal of Falsterbo.

Polyhalobe pleioeuryhaline.

Chaetomorpha melagonium (Web. et Mohr) Kütz.

Distribution Sweden: Bohuslän and Halland, Kylin (1949); Kullen, Levring (1935); Malmö, Hylmö (1916); Öregrund, Waern (1952).

Denmark: Kattegatt, Samsö, Smålandshavet.

This species is found abundantly throughout the whole investigation area from 0.5 - 27 m in depth but most frequently from 8 - 15 m. In the south part it is found from 2 m in depth. It grows solitarily on stones, mollusc shells and sometimes on larger algae, e.g. *Fucus serratus* and *Laminaria stipes*. The length

of the filaments is 5 - 15 cm and on some occasions up to 25 cm. The cells vary from about 300 - 600 x 300 - 750 μ . The period of growth is mainly from March to June; in the south part of the area maybe a little later, from May to August.

Localities: Abundant in the whole area.

Polyhalobe pleioeuryhaline.

Cladophora flexuosa (O.F. Müll.) Kütz.

Distribution Sweden: Bohuslän and Halland, Kylin (1949); Kullen, Levring (1935); Malmö, Hylmö (1916).

Denmark: Kattegatt, Samsö, Smålandshavet, Baltic Möen.

Cladophora flexuosa is abundantly found in the north and central part from 0.5 - 5 m in depth as solitary specimens growing on stones or larger algae. The specimens obtained from below 3 m in depth are most probably loose-lying and often intermingled with other algae. Specimens have been found from March to December.

Localities: Abundant in the north and central part.

Polyhalobe mesoeuryhaline.

Cladophora fracta (Vahl) Kütz.

Distribution Sweden: Bohuslän and Halland, Kylin (1949); Malmö, Hylmö (1916); Blekinge, Levring (1940); Öregrund, Waern (1952).

Denmark: -

The distribution of this species along the Swedish west-coast is poorly known, since most of the herbarium specimens referred to as *Cladophora fracta* have been found to be *Cladophora flexuosa* according to Söderström (1963). The species is found in varying amounts loose-lying together with detached *Cladophora glomerata* in shallow bays with low water circulating, e.g. Lomma Bay and Lundåkra Bay. The author has never found it in an attached state. Specimens have been found from May to July.

Localities: Lundåkra Bay, Salviken, Lomma Bay.

Polyhalobe pleioeuryhaline.

Cladophora glaucescens (Griff. ex Harv.) Harv.

Distribution Sweden: Bohuslän and Halland, Kylin (1949); Kullen, Levring (1935); Malmö, Hylmö (1916).

Denmark: Samsö, Öresund.

This species is common in the north and central part and sparse south of Malmö. It grows at sheltered to semi-exposed localities, belt-forming from the 0-line down to 1 - (2) m in depth, often together with *Cladophora glomerata*. The author is of the opinion that the species has decreased in number during the last years due to competition for space from *Cladophora glomerata*. The specimens are 15 - 25 cm long. Growth begins in March and fully developed specimens are found in June. During the summer the growth rate seems to be very low. The species disappears in September and October. Fertile specimens are seen from May to September.

Localities: Common in the north and central part; Saltholm, Limhamn, Klagshamn, Bredgrund, Skanör.

Polyhalobe mesoeuryhaline.

Cladophora glomerata (L.) Kütz.

Distribution Sweden: Halland, Kylin (1949); Kullen, Levring (1935); Malmö, Hylmö (1916); Blekinge, Levring (1940); Öregrund, Waern (1952).

Denmark: Smålandshavet, Öresund, W. Baltic, Baltic Möen.

This species which is a fresh and brackish water alga is common in the whole of the Öresund. It has, however, increased rapidly both in number and size especially in the north part of the area during the last decade. The species forms at sheltered and semi-exposed localities dense belts from the 0-line to 1.5 - (3) m in depth.

The length of the specimens can reach 25 - 50 cm. Growth begins in March and the maximum size is reached in the beginning of June. At this stage the alga is as a rule detached and is either washed ashore or continues to grow lying loose on the bottom for some time. The loose-lying specimens decay during July. The remaining basal parts on the cliffs and stones seem to continue their growth during summer but do not become more than 15 - 20 cm long. They do not thrive very well and are greyish-green in colour. In September some years more active growth can take place. Most of the specimens disappear in the beginning of October. Fertile specimens have been observed from April to October.

Localities: Common in the whole area.

Polyhalobe pleioeuryhaline.

Cladophora pygmaea Reinke

Distribution Sweden: Bohuslän, Strömmarna, Waern (1940); Henån, Söderström (1963).

Denmark: -

This minute *Cladophora* species which does not exceed 1 mm in length has only been found on two occasions in Scandinavian waters according to Söderström (loc. cit.). The author has found it at four localities in the Öresund. In three of the cases it completely covered small stones 4 - 6 cm in diameter dredged at 10 - 15 m in depth from slightly muddy bottoms in March (Fig. 120). The fourth find which consisted of some single specimens was made at Kullen in July. These grew at an exposed locality 0.2 m below the 0-line between *Balanus balanoides*.

The specimens were 0.7 - 1.3 mm long and the cells varied between 30 - 50 x 35 - 60 μ . These are more constant figures, which agree with Reinke's measurements, than those given by Söderström (loc. cit.) which reported a cell-breadth down to 14 μ .

Localities: Kullen, W. Helsingborg, off Barsebäck, Saltholm flack.

Polyhalobe meioeuryhaline.

Cladophora rupestris (L.) Kütz.

Distribution Sweden: Bohuslän and Halland, Kylin (1949); Kullen, Levring (1935); Malmö, Hylmö (1916); Blekinge, Levring (1940); Öregrund, Waern (1952); Söderhamn, Krok (1869).

Denmark: Kattegatt, Samsø, Smålandshavet, Baltic Möen

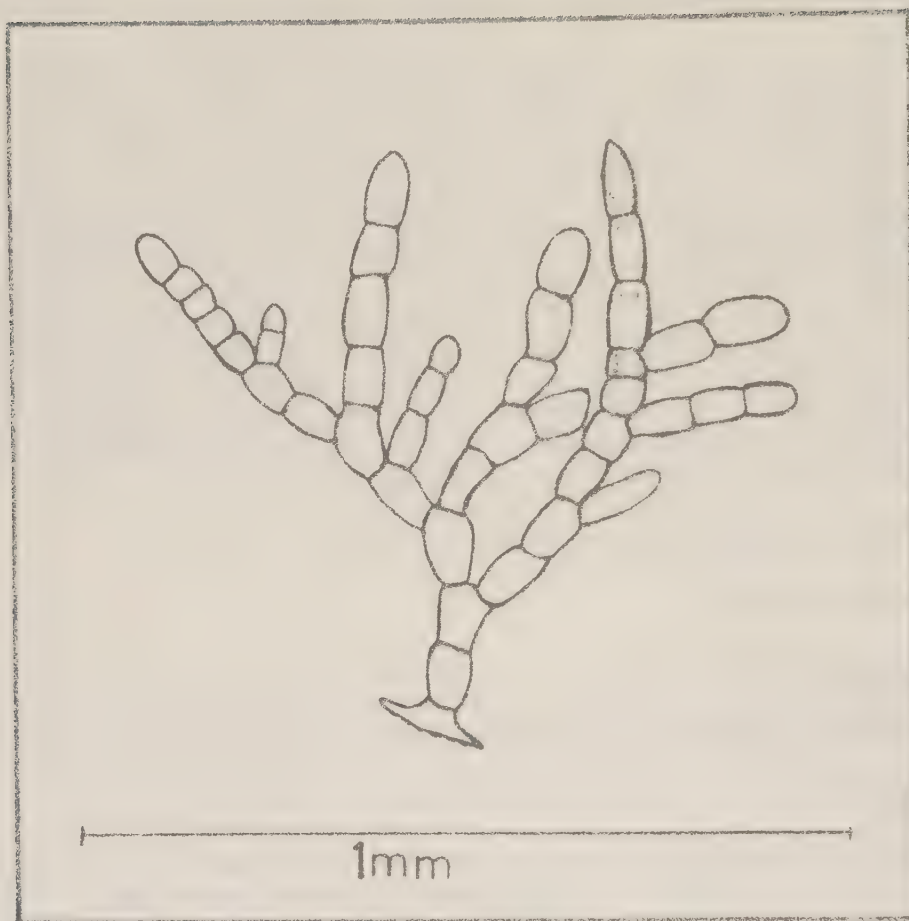


Fig. 129. *Cladophora pygmaea* from Barsebäck.

Cladophora rupestris is common in the whole Öresund area at shaded localities or below fucoids, on stones and cliffs. It is belt-forming from 0.2 - 1.5 m in depth. Between 1.5 - 15 m in depth solitary specimens are abundantly found and below 15 m in depth it has been found on some occasions. Whether these deep-water specimens really have grown at these depths is hard to say. They may be loosely-lying. But in all cases they have been in good condition. At Kullen the species has also been found at shaded low-lying rock-pools from 0.5 m above the 0-line.

The length of the thalli varies with depth. The longest specimens are found in the upper part of the sublittoral zone and in the littoral zone and are 10 - 12 - (15) cm long, and at greater depth (10 - 15 m) 4 - 8 cm long. The species is found throughout the year. Growth is vigorous in (February) - March - May, the main part of the specimens decaying from November to survive as small creeping filaments. Fertile specimens have been observed from April to August.

Localities: Common in the whole area.

Polyhalobe pleioeuryhaline.

Rhizoclonium implexum (Dillw.) Kütz.

(*Rhizoclonium kochianum* Kütz.)

Distribution Sweden: Bohuslän, Kristineberg, Kylin (1949); Kullen, Levring (1935); Malmö, Hylmö (1916); Blekinge, Levring (1940).

Denmark: N. Kattegatt.

This little green alga, which undoubtedly is rare in Scandinavian waters, has been found on two occasions, from 2 and 10 m in depth, respectively. In both cases it was found growing on *Polysiphonia nigrescens* and *Polysiphonia urceolata*. It consisted of 2 - 3 mm big cushions intermingled between the branches of the *Polysiphonia* thalli. The cells were 13 - 20 x 15 - 40 μ . The species was found in July and August.

Localities: Lerhamn, Grälleggrund.

Polyhalobe pleioeuryhaline.

Rhizoclonium riparium (Roth) Harv.

Distribution Sweden: Bohuslän and Halland, Kylin (1949); Kullen, Levring (1935); Malmö, Hylmö (1916); Blekinge, Levring (1940); Öregrund, Waern (1952).

Denmark: Kattegatt, Samsö, Great Belt, Smålandshävet, Öresund, W. Baltic, Baltic Möen.

This species is commonly found on sandy and muddy meadows by the shore, where it forms a light yellow-green carpet, often intermingled with grass. On such shore meadows *Rhizoclonium riparium* is always, but in varying frequency, found together with *Percursaria percursa*. Sometimes the species is also found at exposed localities from 0.5 m below the 0-line up to 3 - 4 m above on fissures in cliffs and larger stones. At such localities with supralittoral *Rhizoclonium riparium* one can often find small runnels with rainwater. The author has not, like Waern (loc.cit.), been able to find this alga, either up to the *Parmelia saxatilis* border or in the sublittoral zone.

The filaments are 1 - 2 cm long and the cells 18 - 25 x 20 - 35 μ . The species is found throughout the year, but the most vigorous growth is seen from February to May and September to October.

Localities: On cliffs: Kullen.

On shore meadows: Common in the whole area.

Polyhalobe pleioeuryhaline.

ACROSIPHONIALES

Acrosiphoniaceae

Acrosiphonia centralis (Lyngb.) Kjellm.

Distribution Sweden: Bohuslän and Halland, Kylin (1949); Kullen, Levring (1935); Blekinge, Levring (1940); Öregrund, Waern (1952).

Denmark: Samsö, Öresund.

Acrosiphonia centralis has no doubt become more abundant in the Sound during the last decades. Levring found the species to be "ziemlich spärlich" at Kullen and Hylmö does not even mention the species from the Malmö area. Today it is wide-spread in the whole area. The species forms a green belt on stones at exposed to rather sheltered localities from (0.25) - 0.5 - 1.5 m below the 0-line. At some very eutrophicated localities it is the dominating species. This extension of the distribution area may be a result of the increasing load of nutrient salts. Such a tendency is also mentioned from the Öregrund area by Waern (loc.cit.).

The species is a conspicuous part of the spring aspect. The first sign of the alga can be seen in January when it is about 0.5 - 1 cm high. Growth is very slow during February and March. In the beginning of April the thalli are about 4 cm high. During April and May growth increases and the maximum length, about 8 cm, is reached in the end of May. At this stage the threads are heavily interwoven. From the end of May and the first part of June the alga is rapidly decomposed, and the colour changes from light green to greyish green. From the middle of June most specimens are dead and quite decayed. Some years very small specimens of the species can also be found in September and October. Fertile specimens have been found from April to the middle of June.

Localities: Common in the north and central part to Landskrona - Copenhagen; frequent south of this line.

Polyhalobe pleioeuryhaline.

Spongomorpha aeruginosa (L.) Hoek

(*Spongomorpha lanosa* (Roth) Kütz.)

Distribution Sweden: Bohuslän and Halland, Kylin (1949); Kullen, Levring (1935); Malmö, Hylmö (1916); Blekinge, Levring (1940).

Denmark: N. Kattegatt, Samsö, Öresund.

Spongomorpha aeruginosa has according to Kornmann (1961 b) and Jónsson (1962) a heteromorphic life-cycle with a sporophyte which is identical to *Chlorochytrium inclusum*. The author has made very few observations of this little endophytic green alga. It is very possible that *Spongomorpha aeruginosa* in the Öresund has an isomorphic life-cycle due to disturbances from the low salinity.

The species is abundant in the Öresund, though Kylin (loc.cit) considers it "spärlich bis selten" along the Swedish west-coast. In the Öresund it is found at somewhat sheltered localities from about 0.5 - 3 m in depth, epiphytically on several algae, such as *Ahnfeltia plicata*, *Ceramium* sp., *Furcellaria fastigiata*, *Polysiphonia* sp. and on *Zostera* leaves. The number of observations of the species seem to decrease towards the southern part of the area.

The thalli consist of loose, interwoven threads which appear as spherical cushions about 1 - 2 - (2.5) cm in diameter. The species is observed during a short period in May and June. In the end of the vegetation period they can often be seen floating freely in rather large numbers. Fertile specimens have been observed in May and June.

Localities: Abundant in the whole area.

Polyhalobe pleioeuryhaline.

Spongomorpha pallida (Kjellm.) Wille

Distribution Sweden: Bohuslän and Halland, Kylin (1949); Kullen, Levring (1935); Blekinge, Levring (1940); Gotland, Svedelius (1901); Öregrund, "found once", Waern (1952).

Denmark: -

Levring (1935) found the species to be rare at Kullen: "nur bei einer Gelegenheit im Juni erhalten". Nowadays, *Spongomorpha pallida* is conspicuously found at exposed localities as a dense belt from about the 0-line to 0.2 - (0.5) m below. At very exposed localities the *Spongomorpha* belt is up to 0.5 m broad. In the south part of the area the species does not form belts but is seen as single specimens or small patches.

The specimens, which are 1 - 2 cm high, are very firmly attached to the rocks and consist of small spherical cushions where the different filaments are linked together. The species is observed from the end of March to the middle of June, more seldom to the beginning of July. On some occasions new small plantlets of the species have also been seen in September and October. Fertile specimens have been found during April to June.

Localities: Common in the north and central part; abundant in the south part.

Polyhalobe pleioeuryhaline.

Urospora penicilliformis (Roth) Aresch.

Distribution Sweden: Bohuslän and Halland, Kylin (1949); Kullen, Levring (1935); Malmö, Hylmö (1916); Blekinge, Levring (1940); Öregrund, Waern (1952).

Denmark: Kattegatt, Samsö, Smålandshavet, Öresund, W. Baltic, Baltic Möen.

Urospora penicilliformis is commonly found from about (1) - 0.5 m above the 0-line to about 0.5 m below.

The filaments are 3 - 6 cm long. The cell diameter of *Urospora penicilliformis* is according to the literature:

	Kylin (1949)	Hylmö (1916)	Levring (1940)	Waern (1952)	Hanic (1965)	
Vegetative parts	30-38	22-68	25-35	6,25-37	100	/u
Fertile parts	50-55	39-69	50	50-69	-	/u

The author's measurements vary from 15 - 30 /u in diameter and the length of the

cell varies from 0.5 - 2 times the diameter. A closer examination of the variation in the cell size in the material from one locality shows that there are differences in different parts of the green belt, which can be seen in the table below. About 90 measurements from each level have been made.

Growth place	Mean values of the cell diameter	
0.4 - 0.5 m above the 0-line	22	/u
0.1 - 0.2 m above the 0-line	26	/u
Around the 0-line	35	/u

In a very large material the size of the cells has been measured. In these measurements one can find a specific group of filaments which have cells which are 18 - 20 x 18 - 20 /u. As a rule these are morphologically identical to *Urospora penicilliformis*, but are in some cases easily mistaken for *Ulothrix*. Such narrow forms have been mentioned by several authors, such as Jaasund (1965). Rosenvinge (1894) has described an *Urospora mirabilis* f. *elongata*. Hylmö (loc.cit.) also found such forms near Malmö. Waern (loc.cit.) mentions "slender" types of *Urospora penicilliformis* from Öregrund, but these have much longer cells, up to 2 - 6 times the diameter.

The species is found from January to the middle of June and from August to November. Fertile specimens are observed from the middle of April to the middle of June, but most frequently from the middle of May. During autumn few fertile specimens are found (in September and October).

Jorde (1933) proved that *Urospora penicilliformis* had a heteromorphic life-cycle with an alternation of the filamentous stage and a *Codiolum* stage (*Codiolum gregarium*). This is apparently not the case in the Öresund as no specimens of *Codiolum gregarium* have been observed.

Localities: Common in the whole area.

Polyhalobe pleioeuryhaline.

Urospora wormskioldii (Mert. in Hornem.) Rosenv.

Distribution Sweden: Bohuslän and Halland, Kylin (1949); Kullen, Levring (1935); Malmö, Hylmö (1916); Blekinge, Levring (1940).

Denmark: N. and S. Kattegatt, Samsø, Öresund.

Urospora wormskioldii is commonly found at exposed to sheltered localities from (1.5) - 1 m above the 0-line to 0.5 m below. There is a tendency to a smaller number of specimens per surface area in the south part of the area.

In the literature there are many divergent pronouncements about the diameter of the cells of *Urospora wormskioldii*:

	Kylin (1949)	Hylmö (1916)	Hanic (1965)	Pankow (1971)	
Basal parts	45-70	46-270	80-200	30-70	/u
Apical parts	120-300	-	100-300 (fertile plants)	-	/u
Cell length = Cell breadth	1-4 (mostly 2)		1-4		

In the author's material the breadth of the cells can vary from 35 - 100 μ but in most cases from 40 - 60 μ . The length of the cells is very variable. In one and the same filament the variation is from 280 - 340 μ . Like in *Urospora penicilliformis*, measurements of the cell diameter from different levels of the green belt at one locality show that there is a tendency to a decreasing diameter towards the upper parts of the green belt. About 90 measurements from each level have been made.

Growth place	Mean values of the cell diameter	
0.5 m above the O-line	39	μ
Around the O-line	52	μ
0.5 m below the O-line	70	μ

A comparison between localities with different salinity shows that there is no variation due to this factor.

The species is found from January to the middle of June and from September to November but seems to be most frequent during spring. Some springs with comparatively warm January and February, the growth is considerable. If March has temperatures below 0° C the *Urospora* species may be severely damaged and completely disappear. When the temperature conditions are more favourable in April, *Urospora wormskioldii* can reach normal size, 8 - 12 cm, in 10 - 20 days. The species is generally fertile from April to June, mostly during the later part of the period. There is often a tendency for sun-exposed specimens to be fertile earlier than specimens growing in shadow.

Kornmann (1961 c) has studied *Urospora wormskioldii* in culture at Helgoland and found a heteromorphic alternation between a unicellular sporophyte stage, identical with *Codiolum gregarium*, a dwarfish plantlet and a filamentous gamophyte stage. He also found that temperature has a very strong influence on the development of the different stages in the life-cycle. However, only *Codiolum petrocelidis* is previously known from Sweden.

The *Codiolum* carpets which Kornmann has found during autumn and winter at Helgoland have not been found in the Öresund or along the Swedish west-coast. The *Urospora* species thus generally have an isomorphic life-cycle in Sweden. Whether this is an effect of the low and changing salinity must be studied by culture experiments.

However, during a close examination of the material from the green belt, collected from April to June, the author frequently found isolated specimens of *Codiolum*. These were not attached to the rocks but on the *Urospora* filaments themselves. The *Codiolum* stage varied from 42 - 63 μ in diameter and the length between 73 - 115 μ . The author is not of the opinion that this *Codiolum* stage, if it belongs to *Urospora wormskioldii*, has any real function in the life-cycle of this species in the Öresund region. (Fig. 121)

Localities: Common in the whole area.

Polyhalobe pleioeuryhaline.

CAULERPALES

Derbesiaceae

Derbesia marina (Lyngb.) Solier

Distribution Sweden: Bohuslän, Kristineberg, Kylin (1949).

Denmark: N. Kattegatt.

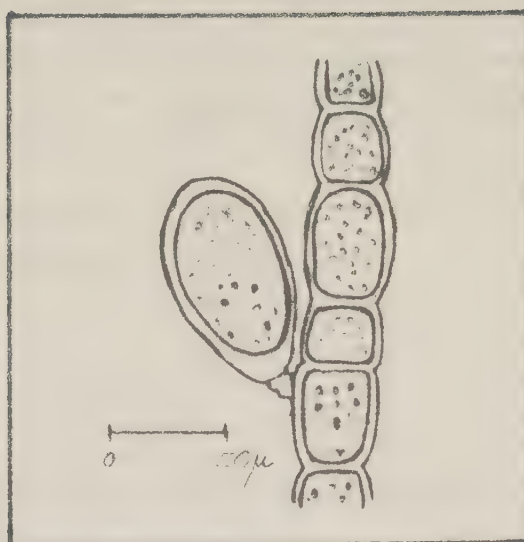


Fig. 121. *Urospora wormskioldii* with a *Codium* stage. From Kullen.

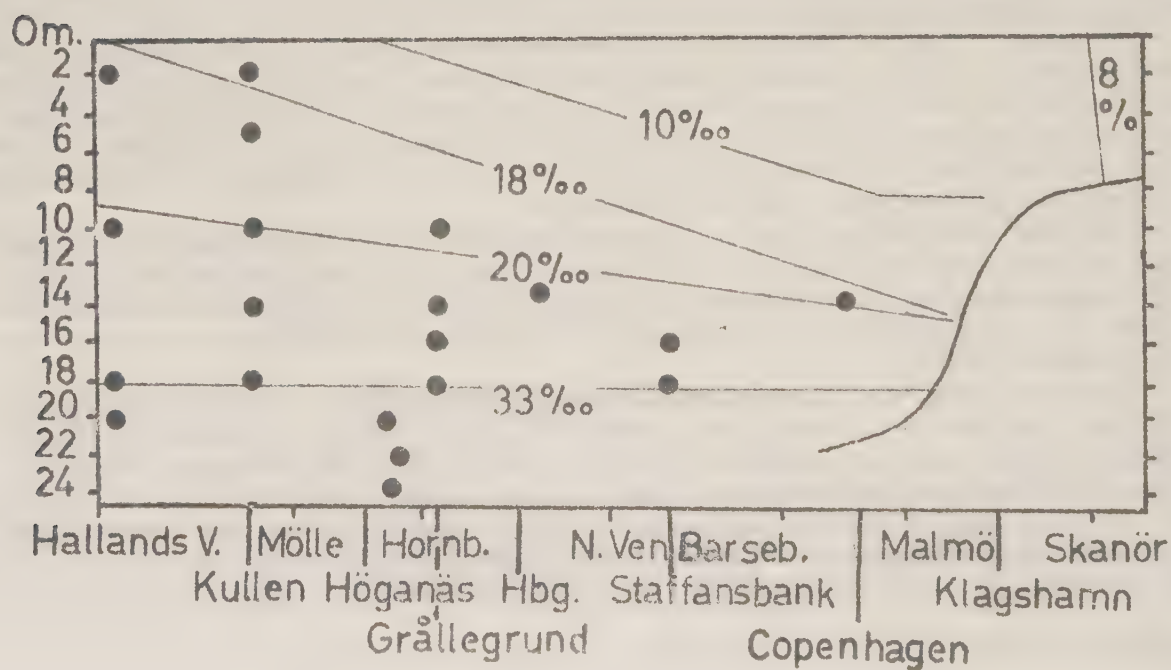


Fig. 122. The distribution of *Bryopsis plumosa* in relation to depth and salinity.

According to Kylin (loc.cit.) *Derbesia marina* is "selten" in Bohuslän and the *Halicystis* stage only found "bei einer Gelegenheit" at Väderöarna in Bohuslän. In the author's opinion *Derbesia marina* is today not uncommon in the north part of Bohuslän.

The species has been found on some occasions growing in the aquaria at the Marine Biological Station at Helsingör and at the Department of Marine Botany in Lund. All material and the water in the aquaria had been collected in the north part of the Öresund. The water was taken from about 30 m in depth. These finds of *Derbesia marina* undoubtedly emanate from diaspores which were brought to the entrance of the Öresund by the saline bottom current. All examined material was sterile.

Locality: Hornbaek Bay.

Polyhalobe oligoeuryhaline.

Bryopsidaceae

Bryopsis plumosa (Huds.) C. Ag.

Distribution Sweden: Bohuslän and Halland, Kylin (1949); Hallands Väderö, Sjöstedt (1927); Malmö, Hylmö (1916).

Denmark: Kattegatt, Samsö.

This species is found irregularly in low numbers in the north and central part of the Öresund. North of, and at, Kullen it is found from (2) - 10 - 25 m in depth, but south of Kullen from 10 - 25 m in depth. It grows on stones and larger mollusc shells. There is a great variation in the number of finds from one year to another and there is also a tendency for fewer finds during the last three years. This variation, however, can partly be explained by the fact that *Bryopsis plumosa* can be very difficult to obtain by dredging due to its slippery consistency. The specimens that have been found vary from 5 - 15 cm in length. On one occasion a specimen 20 cm high was found. The species is observed from March to November.

Localities: Hallands Väderö, Kullen, Vattenmöllan, Hornbaek Bay, Grälleggrund, Disken, Staffansbank, Saltholm flack. (Fig. 122)

Polyhalobe meioeuryhaline.

Codiaceae

Codium dichotomum (Huds.) S.F. Gray

(*Codium fragile* ssp. *scandinavicum* Silva)

Distribution Sweden: Bohuslän, Kylin (1949).

Denmark: Kattegatt, Samsö.

In the herbarium at the Botanical Museum in Lund there are three sheets with *Codium dichotomum* collected in the Öresund. Two of these are from Helsingborg and one from Barsebäck. The Helsingborg specimens were found loose-lying after a heavy northwesterly storm (S.O. Nielsen, personal communication). The specimens from Barsebäck was collected by Sjöstedt and according to a notation on the sheet it was dredged from 6 m in depth.

The author has not been able to find any *Codium dichotomum* in the Öresund area. The Barsebäck specimen is, therefore, without doubt a drifting specimen.

The author has found a loose-lying *Codium dichotomum* at Kullen in 1961, but since then the species has not been met with in the Öresund area. The southernmost locality in Kattegatt where the author has found the species is 10 km west of Gilleleje at Tidsvildeleje from 5 - 10 m in depth on a stone reef just outside the present investigation area.

Locality: W. of Gilleleje flack (Tidsvildeleje).

Polyhalobe meioeuryhaline.

Chaetosiphonaceae

Blastophysa rhizopus Reinke

Distribution Sweden: Bohuslän and Halland, Kylin (1949); Kullen, Levring (1935).

Denmark: N. Kattegatt.

Levring (loc.cit.) has observed both *Blastophysa rhizopus* and *Blastophysa polymorpha* a few times at Kullen, and Kylin (loc.cit.) states "gemein bis spärlich" along the Swedish west-coast. In spite of microscopic investigation of a large material from all over the Öresund, the author has not been able to find the species.

Locality: -

Polyhalobe meioeuryhaline.

Phyllosiphonaceae

Ostreobium quekettii Born. et Flah.

Distribution Sweden: Bohuslän and Halland, Kylin (1949); Kullen, Levring (1935); Malmö, Hylmö (1916).

Denmark: N. Kattegatt, Smålandshavet.

The systematic status of this genus is a little dubious. Kylin (loc.cit.) has placed the genus in the order Siphonales. Christensen (1966) has moved Phyllosiphonaceae to Chlorococcales and suggests that it might be a link to Caulerpaceles. The sparse appearance of transverse cell walls could perhaps justify placing it in Chlorococcales. Dawson (1966) has moved the genus to Vaucheriales without comment.

Ostreobium quekettii is found from 2 - 20 m in depth in mollusc shells, e.g. *Cardium*, *Macoma*, *Mya* and in balanids. It is often seen together with *Conchocelis* sp.

Localities: Common in the north and central part; frequent in the south part.

Polyhalobe mesoeuryhaline.

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